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Institute of Polar Studies
Report No. 50

PALEOECOLOGICAL INVESTIGATIONS OF DIATOMS IN A CORE FROM KERGUELEN ISLANDS, SOUTHEAST INDIAN OCEAN

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The Ohio State University
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ERRATUM: Page 37, paragraph 2, "past deposition" should read "peat deposition"

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ABSTRACT

Percentage frequencies of diatom taxa from 20 levels in a sediment core from Kerguelen Island, Southeast Indian Ocean were considered in light of known present ecological preferences, and populations at varying levels compared. By using diatoms as environmental indicators, and also considering physical stratigraphy, environmental conditions prevailing on Kerguelen during the past 10,000 years were reconstructed. Comparisons were also made between depositional environment information determined by diatom studies and conclusions reached by Young and Schofield in a 1972 pollen analysis using soil samples from the same levels in the Kerguelen core.

ACKNOWLEDGMENTS

I would like to thank Dr. Gary B. Collins for suggesting the project, Eileen Schofield for supplying the core material, and Dr. Clarence Taft for valuable comments on the manuscript. Most special thanks go to Dr. Robert Kalinsky for help and suggestions throughout the course of the study. Field work and collection of the core were done by Dr. Steven B. Young with support from National Science Foundation Grant GV-26139 awarded to The Ohio State University Research Foundation and the Institute of Polar Studies.

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INTRODUCTION

Location and Description

Kerguelen Island is the largest island of the 6,500 km^2 Kerguelen Archipelago in the southern Indian Ocean, located at about 48.5° - 49.5° S latitude and 68.5° - 70.5° E longitude (Young and Schofield, 1973). The area is considered subantarctic by geographers, being located at the Antarctic Convergence (Young and Schofield, 1973). One-quarter of Kerguelen Island is covered with glacial ice, mostly on the western side, but the area in which the core under investigation was taken was deglaciated 10,000 - 12,000 years ago (Young, 1971).

Kerguelen is volcanic, with Mount Ross, an extinct volcano, its highest point. The 2,080-meter-high peak is now snow-covered at all times of the year. The island measures 131 by 121 km, and is irregular in shape with deeply indented coasts (Fig. 1). Only the coastal areas support wildlife; penguins, cormorants, albatrosses, petrels and elephant seals are found on the eastern side of the Courbet Peninsula where the coast is flat and marshy (Migot, 1956). Due to its proximity to the Antarctic Convergence, Kerguelen is exposed to violent northwesterly winds during all seasons of the year, accompanied by deep barometric depressions (Murray, 1885). Migot (1956) has suggested that this climate, comparable to that of Greenland or Iceland, has made it impossible for any type of tree or shrub to survive on the island.

According to Young (1971) approximately 30 species of higher plants grow on Kerguelen, none of them woody. Hooker (1847) reported 21 flowering plants, two club mosses and seven ferns. Although there are presently no

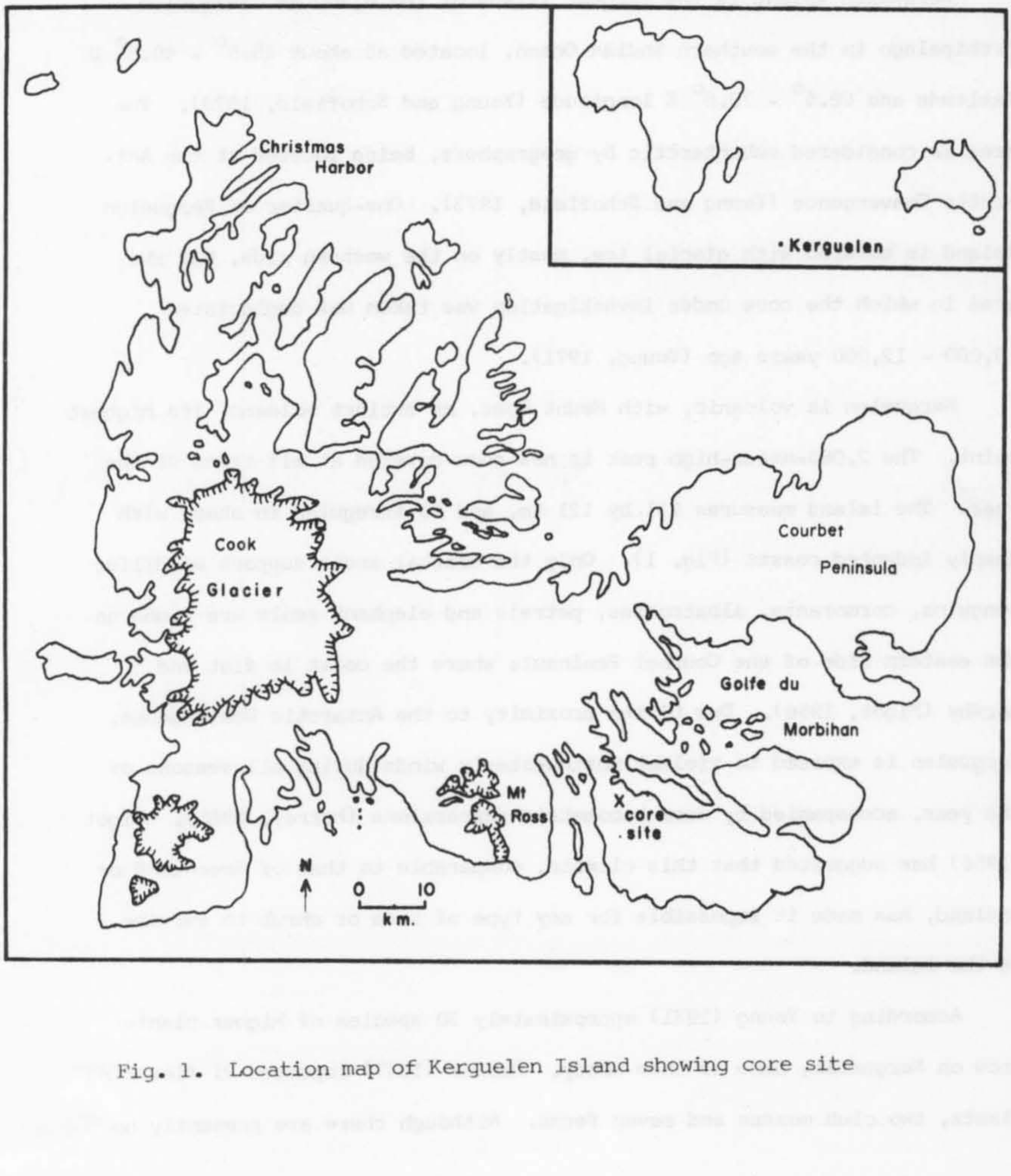

Fig. 1. Location map of Kerguelen Island showing core site

woody plants on the islands, the report of the 1874 Challenger exploration on Kerguelen states that fossil wood was found on the south side of Christmas Harbor (Murray, 1885).

Although its location is subantarctic, temperatures on Kerguelen seldom fall below freezing, the mean summer temperature being 8°C and the mean winter temperature 1°C (Young and Schofield, 1973). Snow may fall during any month of the year, but remains only two to three days (Murray, 1885).

Diatoms were collected from four freshwater sites and one brackish situation during the Challenger expedition in 1874 (O'Meara, 1877). The most recent and extensive freshwater diatom flora for the island was published in 1954 by Bourelly and Manguin, an excellent taxonomic reference.

The diatom flora reported by Bourelly and Manguin includes 160 taxa representing 27 genera, 84 species, 62 varieties and 14 forms collected from four locations; two lakes, a river and a peat bog. They described 47 new taxa as endemic to Kerguelen, and suggested that this was due to the climatic conditions which prevail in the area. The algal taxa reported exclusive of the Bacillariophyceae were described by Bourelly and Manguin as cosmopolitan and typical of colder regions.

History

During the past 50 years, pollen analysis has become increasingly accepted as a valuable ecological tool in reconstruction of former plant communities. By inspection of the plant communities recorded in the fossil record during successive periods, environmental changes with time may be determined (Sears, 1930). Pollen from buried sediments has been useful in helping to date buried animal remains in peaty deposits (Potzger, 1941). Davis (1963) described the standard North American pollen sequence as a transition from herb pollen to spruce to pine to deciduous tree pollen, and states that this successional pattern has been observed repeatedly in studies of core material.

Diatoms have also been used in reconstructing past environments. Ehrenberg (1854) was one of the first to study diatoms from sediments (Stoermer and Yang, 1968). Taylor (1929) observed that diatoms in sediments indicated whether deposits had formed in fresh or brackish water and that "from the genera and species therein contained the presence in the locality of primeval lakes or seas may be known; the contours of their beds may be indicated by the presence of pelagic or littoral forms; and the climate at the time of the deposit; whether temperate, tropical or arctic may be ascertained."

One of the earliest to reconstruct past environments by using diatoms was Conger (1939). He studied diatoms in cores from Crystal Lake, Wisconsin, and found that in the past the lake had been less acidic and richer in nutrients than during the time of his study (Frey, 1963). Pennington (1943) noted a "marked difference" between diatom floras of deposits from deep and from shallow waters during a study of pollen and diatoms from Lake Windemere, England. At that time, she commented on the possible value of diatoms in sediments for studies of lake succession, but mentioned that there was little information available on ecological tolerances.

Stockner and Benson (1967) have linked relative frequencies of Melosira italica and Fragilaria crotonensis to recent (about 1860) enrichment of Lake Washington, near Seattle, Washington. Assuming M. italica to indicate oligotrophic conditions and F. crotonensis mesotrophic to eutrophic conditions, and also assuming a sedimentation rate of 2.5 mm per year, the levels of these diatoms relate directly to enrichment with raw, and then treated, sewage.

Stoermer and Yang (1968) noted an increased number of individuals in more recent sediments of Lake Huron and associated this with increased eutrophication as the lake matured. In a 1971 study Stoermer et al. used diatom floras in sediments to demonstrate that Devils Lake in North Dakota has had a continuous high level of dissolved solids throughout its history.

Information on the ecological distribution of diatoms and other algae has been published by Hustedt (1937), Petersen (1943), Foged (1954), Douglas (1958), Crosby and Ferguson-Wood (1959), Fjerdingstad (1965), Cholnoky (1968) and others. These studies have increased the value of fossil diatoms as indicators, making possible the reconstruction of a past ecological situation in detail. Diatoms can provide detailed evidence for a limited area; pollen analysis provides a less detailed picture of past ecological situations over a wider geographic area.

Few workers have attempted to compare pollen and diatoms from the same core levels. Patrick analyzed diatom frequencies in core material from Lago di Monterosi in Italy, where pollen analysis had also been done (Patrick, 1962), and Haworth (1972) related diatom and pollen frequencies in cores from Pickerel Lake in South Dakota.

This study is intended as a corollary to the pollen analysis of Young and Schofield (1973), and utilizes the same core material. Their pollen study did not show the classic successional pattern of many pollen profiles from both hemispheres, because the core contains no arboreal pollen.

In attempting to reconstruct the climatic history of the Kerguelen Islands area, Young and Schofield concerned themselves primarily with a comparison of two genera, *Azorella* and *Acaena*. These genera were also used in an analysis by Schalke and van Zinderen Bakker (1971) of pollen from Marion and Prince Edward Islands (Young and Schofield, 1973).

Young and Schofield used the ratios of pollen from *Azorella*, the umbelliferous "cushion plant", and *Acaena*, a member of the Rosaceae, to indicate prevailing climatic conditions at the time of deposition. *Azorella selago* Hook. f. presently occurs in dry, exposed upland areas, and is considered to be a cold-tolerant plant. The lower, wetter, warmer regions are presently dominated by *Acaena adscendens* Vahl. Also typical of the warmer lowland condition are *Lycopodium saururus* Lam., *Blechnum penna-marina* (Poir.) Mitt., *Uncinia compacta* R. Br., and *Galium antarcticum* Hook. f., now found at Kerguelen at elevations below 220 meters (Young and Schofield, 1973).

Lycopodium, *Blechnum* and *Uncinia* appeared in the core at about 8,000 to 9,000 B.P. At this time the concentration of *Azorella* was low, with *Acaena* pollen abundant. The predominance of "lowland" indicators persisted until about 6,000 years B.P., at which time *Galium* pollen increased, indicative of a drier trend.

"Lowland" genera present in large concentrations in the core indicate a warmer climate than that which presently exists at Kerguelen. By 5,000 years B.P., frequencies of pollen in the "lowland" genera decreased, and this has been interpreted as indicating a cooling trend. This history is in accordance with worldwide climatic trends for the southern hemisphere (Heusser, 1966).

MATERIALS AND METHODS

The sediments under investigation were obtained from a stream bank composed primarily of organic silts and blanket peat on the south shore of the Golfe du Morbihan, Kerguelen Island, by Dr. Steven B. Young in early 1971. He used a series of 12-oz beverage cans to remove a 308-cm-long core in sections. After arrival at The Ohio State University, the sediments remained under refrigeration in these containers until preparation for pollen analysis was begun later that year (E. K. Schofield, personal communication). At that time two concurrent sets of soil samples were removed at 6- to 8-cm intervals along the total length of the core and placed into vials. Therefore material from the same levels along the core was available for use in both the pollen and diatom studies.

The soil samples used in the diatom study were first soaked in distilled water to disassociate the particles from fibrous debris, and approximately one hour later 100 ml of 30% hydrogen peroxide was added, along with about 0.1 g of potassium dichromate. The reaction was left to proceed to completion. When the cleaning solution had turned from purple to yellow in color, a series of distilled water decantations at four-hour intervals were made, until there was no further trace of yellow coloration to the water. Slides were made using Hyrax diatom mounting medium. Replicate slides were prepared at each level.

At each of 20 levels 1,000 diatom valves (500 on each of two replicate slides) were counted and taxon percentages recorded. The diatom frustules were badly broken at some levels, and extremely sparse at others. At these levels counts were not made. This explains the irregular spacing of levels where diatoms were counted along the core. The strip method of counting was used throughout, under oil immersion (1000x). Counts of the 105 taxa recorded from the core are included as Appendix 1 in Larson (1973) and percentages based on these counts are used for the diagrams illustrating percentage frequency per level (Figs.5 - 17).

Radiocarbon dates determined by Teledyne Isotopes are included as part of Fig. 3. Before radiocarbon analysis, the samples were treated for the removal of humic acid and carbonates. Dr. Kaye R. Everett (Institute of Polar Studies and the Department of Agronomy, The Ohio State University) analyzed and described the core sediments (Appendix 3).

Percentage frequency curves for the 56 most commonly occurring diatom taxa are plotted in Fig. 3. These are presented in groupings according to pH tolerance. Ecological information for these 56 taxa is included as Appendix 2.

Diversity index and ordination computer programs (Orloci, 1966) were used for comparison of the 20 communities. Two-dimensional ordination data were plotted to compare populations, and diversity index by station is included on the same figure (Fig. 18).

The pH measurements of the soil at each of the 20 levels at which counts were made were determined using an Orion Research pH Meter. Soil was suspended in double-distilled water, the pH measured, and values included as Table 1.

Physical Description of Core

Dr. Kaye R. Everett examined the Kerguelen core. His profile description is included as Appendix 3, and a soil profile based on his description is included as part of Fig. 3.

He visualizes the possible environment of deposition at the core site as a shallow basin with relatively uniform peat accumulation in shallow water, and a high rate of decomposition. Conditions later became those of a bog, as evidenced by a lesser degree of decomposition of organics.

With time the core material became still lower in organics, and a drier climate is indicated by an increased percentage of silt. This drying trend is further evidenced by the presence of sedge fragments. In the upper layers, zones of "sand" or "coarse sand" have probably been blown into the basin from the surrounding hillsides, as they are angular and not rounded by stream washing. Although the upper layers indicate a drier climate, mottling of the most recent soil is an indication that the water table has remained close to the surface.

RESULTS

The diatom population throughout the Kerguelen core is generally dominated by Fragilaria leptostauron var. dubia, Fragilaria construens var. venter, and Fragilaria virescens var. subsalina. Diatomella Hustedtii occurs as a dominant at 19 of the 20 core levels. Most of the same taxa occur throughout, indicating that conditions at the site have been relatively stable. The total number of taxa occurring at each core level fluctuates, but high numbers at various levels throughout the core indicate a fairly complete population from top to bottom (Fig. 2).

Of the 105 taxa recorded from the core, 86 were also found on Kerguelen by Bourelly and Manguin in 1954. These are indicated in Appendix 1 by an asterisk (*) preceding the taxon name. The 56 most commonly occurring diatom taxa from the core material are included in a percentage frequency per level diagram along with the major six pollen types found by Young and Schofield (1973). Ecological data are given for these 56 diatom taxa in Appendix 2, and Figs. 5 through 17 illustrate percentage frequency per level of diatoms falling into particular ecological categories, and are based only upon these 56 most abundant taxa for which information is listed.

Diatom taxa occurring in concentrations greater than 5% at each level, along with their percentages, are included as Appendix 4. These are considered the dominants at each level.

The pH values (Table 1) obtained for the soil at each of the 20 core levels did not seem to indicate any relationship to environment of deposition or diatom population, possibly due to leaching of the sediments.

Coordinates obtained by using a computer program which determines ordination by station (Orloci, 1966) were plotted as a two-dimensional graph (Fig. 18). An index of diversity program by Orloci was also run, and these values are included in Fig. 18. No correlation was noted between diversity index and core depth. Groupings obtained by ordination were not satisfactory, there being too many random points.

Level	Genera	Taxa
1	21	69
2	20	62
3	19	64
4	20	68
5	16	57
6	20	56
7	18	48
8	19	49
9	20	57
10	14	51
11	20	55
12	18	40
13	19	46
14	18	33
15	17	41
16	20	56
17	16	49
18	12	27
19	19	53
20	16	49

Total Number of Genera: 23

Total Number of Taxa: 105

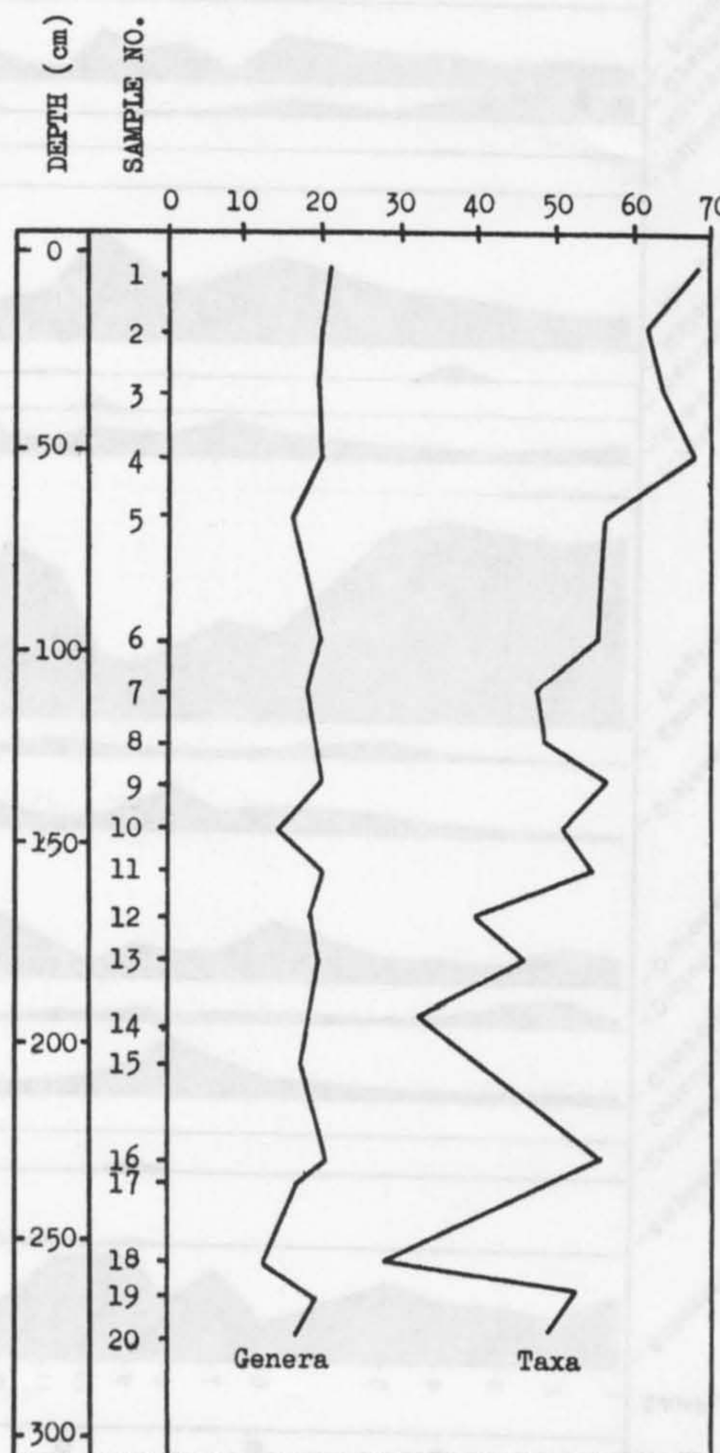

Fig. 2. Total number of genera and total number of taxa per level in Kerguelen core

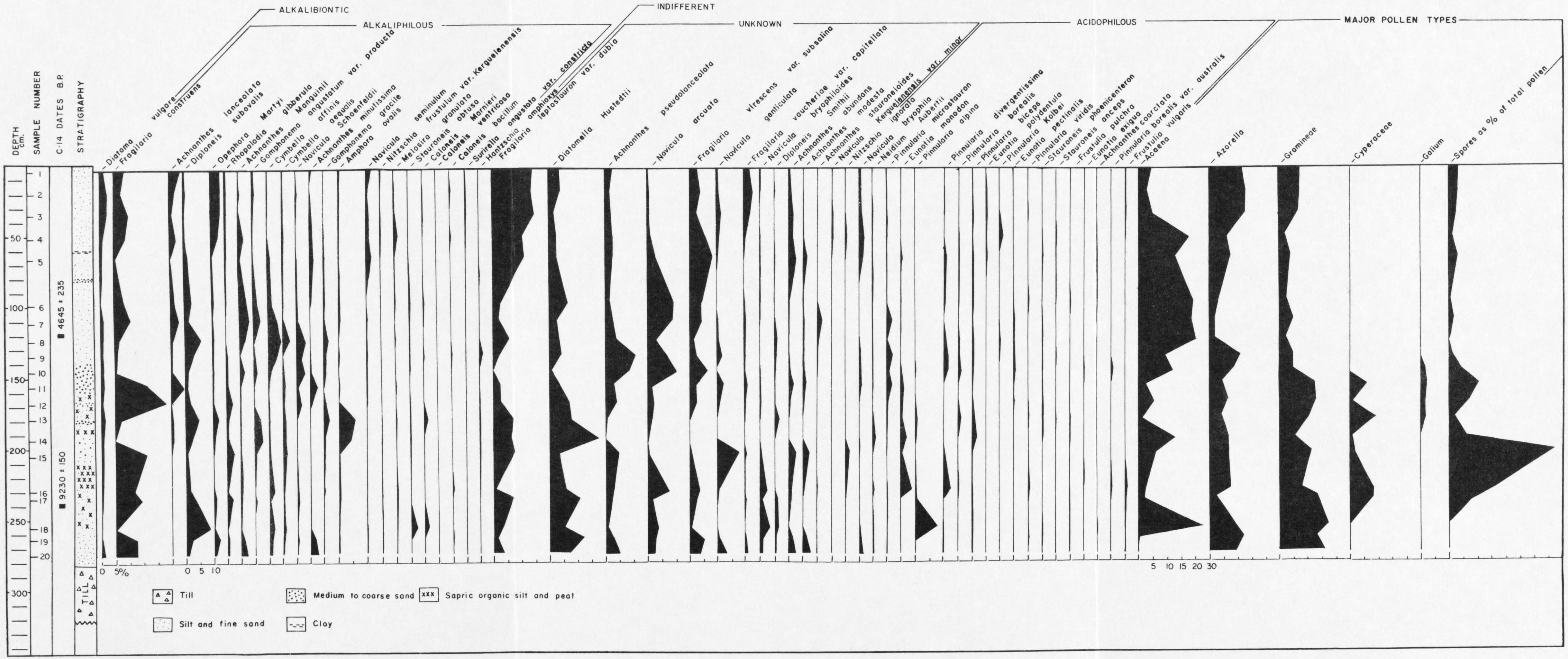

Fig. 3. Percentage frequency per level of 56 most commonly occurring diatom taxa and 6 major pollen types from Kerguelen core

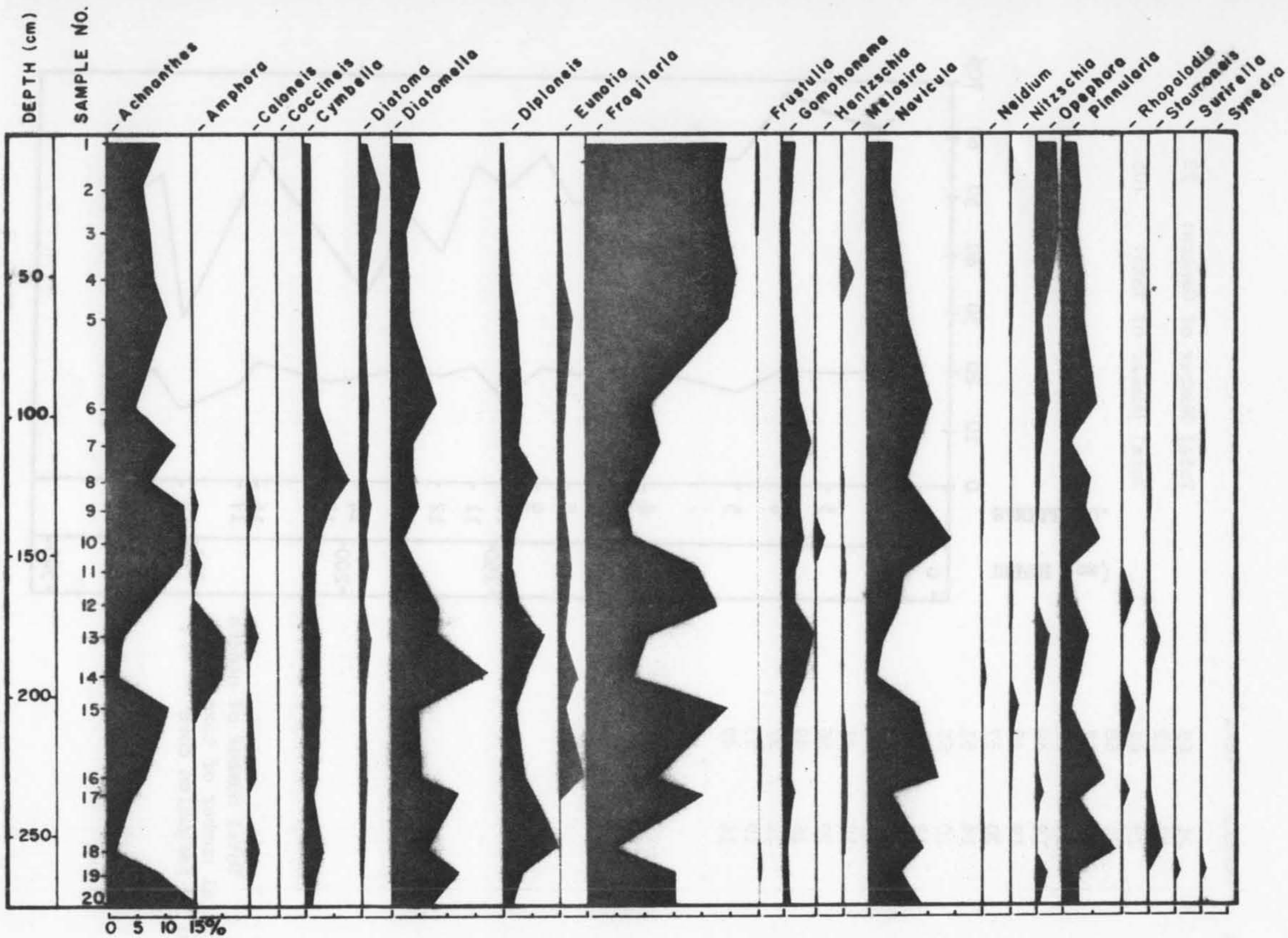

Fig. 4. Percentage frequency per level of all diatom genera in Kerguelen core

Taxa:

Fragilaria construens
var. venter
Fragilaria leptostauron
var. dubia
Fragilaria vaucheriae
var. capitellata
Fragilaria virescens
var. subsalina
Melosira granulata
Navicula Kerguelenensis
fo. minor
Pinnularia borealis
var. australis

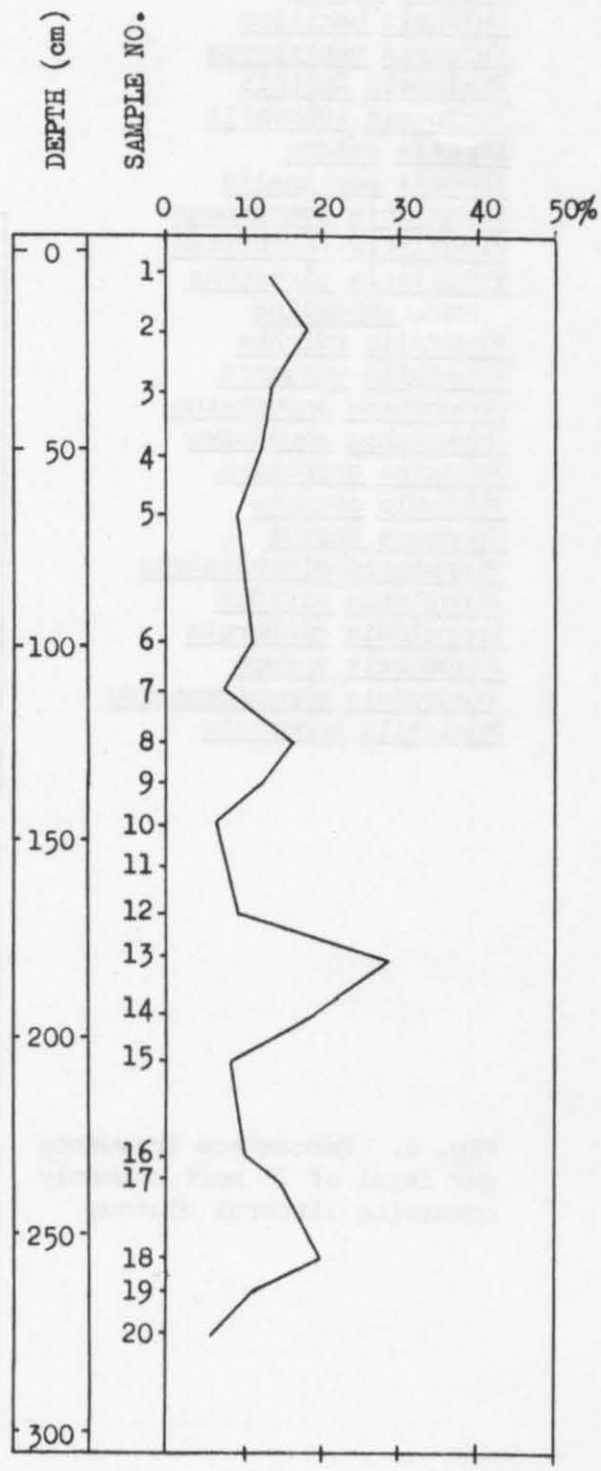

Fig. 5. Percentage frequency per level of 7 most commonly occurring planktonic diatoms

Taxa:

Achnanthes lanceolata
Achnanthes pseudolanceolata
Amphora ovalis
Caloneis bacillum
Caloneis ventricosa
Diploneis Smithii
Diploneis subovalis
Eunotia exigua
Eunotia pectinalis
Fragilaria construens
Fragilaria vaucheriae
Fragilaria virescens
  var. subsalina
Frustulia pulchra
Frustulia vulgaris
Gomphonema angustatum
Hantzschia amphioxys
Melosira granulata
Navicula arcuata
Opephora Martyi
Pinnularia microstauron
Pinnularia viridis
Rhopalodia gibberula
Stauroneis anceps
Stauroneis phoenicenteron
Surirella angustata

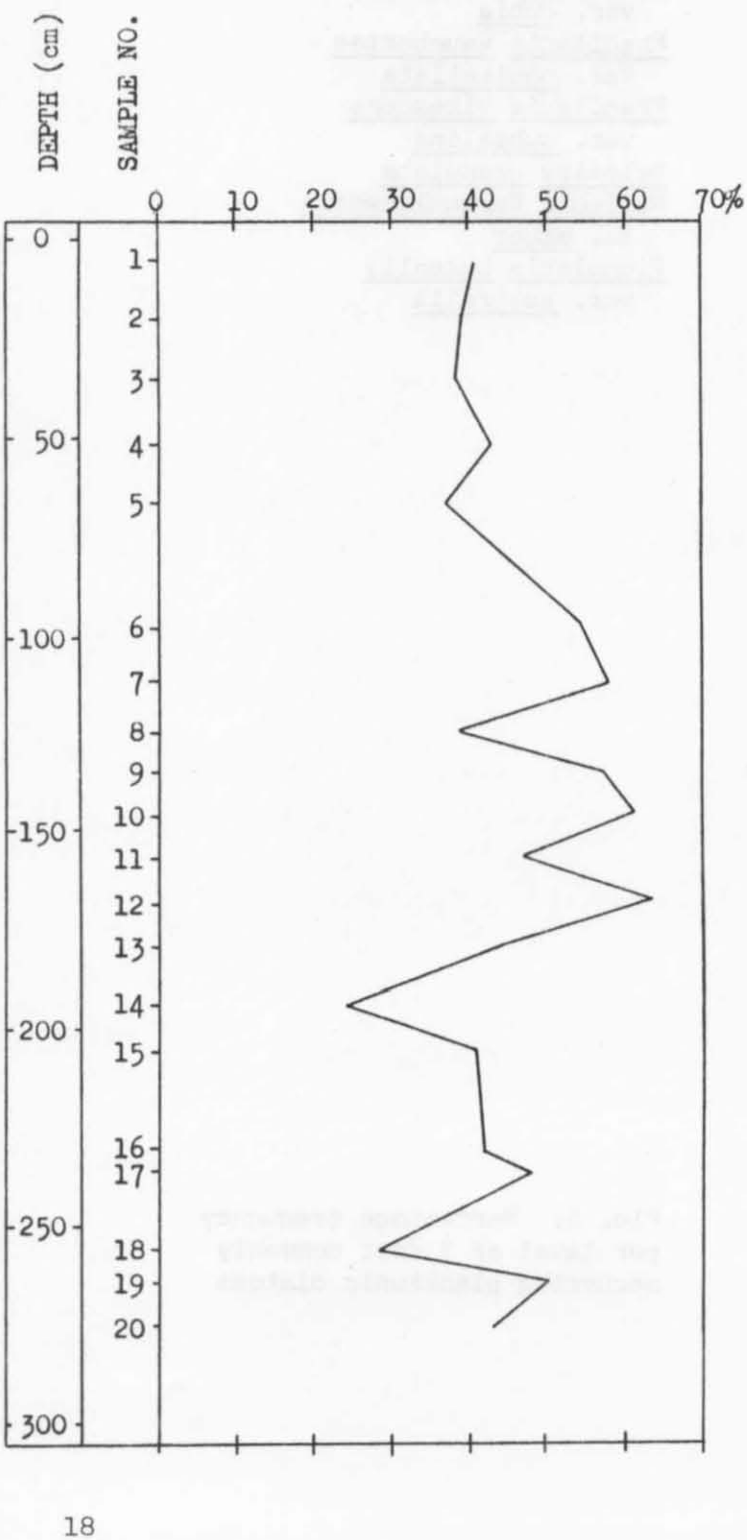

Fig. 6. Percentage frequency per level of 25 most commonly occurring littoral diatoms

Taxa:

Caloneis bacillum
Diploneis Smithii
Diploneis subovalis
Neidium Aubertii
Pinnularia alpina
Pinnularia borealis
  var. australis
Pinnularia borealis
Pinnularia divergentissima
Pinnularia Kolbei
Pinnularia microstauron
  var. elongata
Pinnularia viridis
Stauroneis anceps
Stauroneis obtusa
Stauroneis phoenicenteron
Surirella angustata

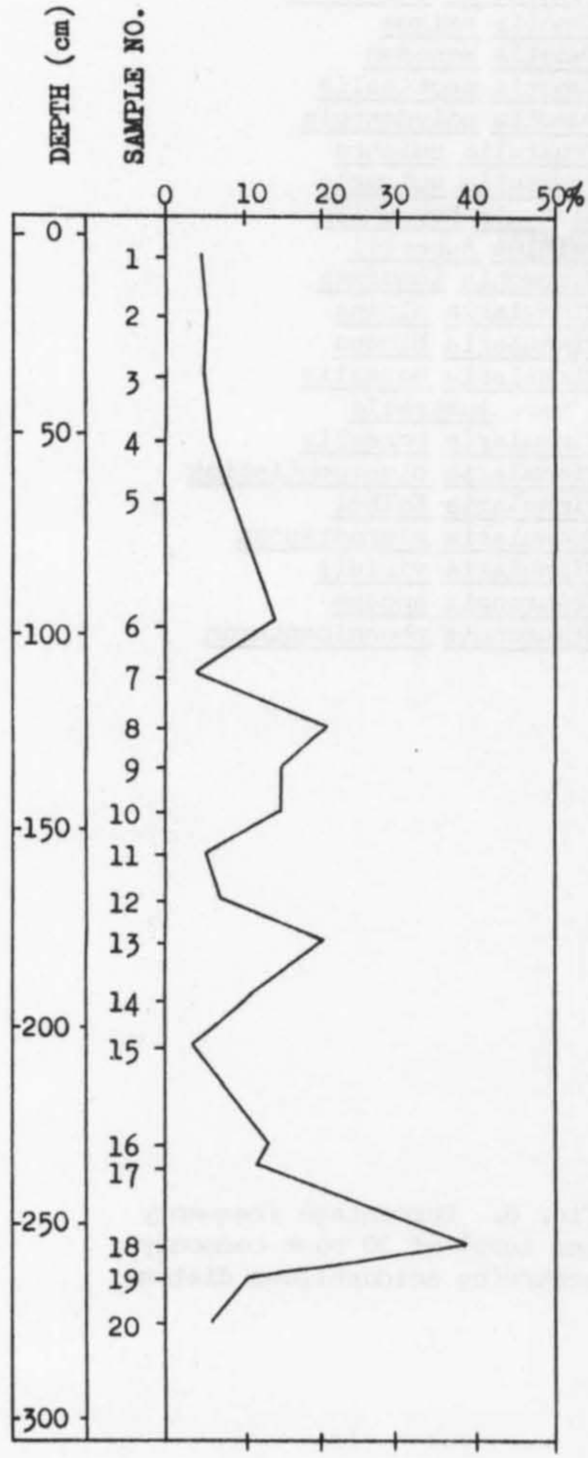

Fig. 7. Percentage frequency per level of 15 most commonly occurring benthic diatoms

Taxa:

<u>Achnanthes</u> <u>coarctata</u>
<u>Eunotia</u> <u>exigua</u>
<u>Eunotia</u> <u>monodon</u>
<u>Eunotia</u> <u>pectinalis</u>
<u>Eunotia</u> <u>polydentula</u>
<u>Frustulia</u> <u>pulchra</u>
<u>Frustulia</u> <u>vulgaris</u>
<u>Navicula</u> <u>bryophila</u>
<u>Neidium</u> <u>Aubertii</u>
<u>Nitzschia</u> <u>ignorata</u>
<u>Pinnularia</u> <u>alpina</u>
<u>Pinnularia</u> <u>biceps</u>
<u>Pinnularia</u> <u>borealis</u>
var. <u>australis</u>
<u>Pinnularia</u> <u>borealis</u>
<u>Pinnularia</u> <u>divergentissima</u>
<u>Pinnularia</u> <u>Kolbei</u>
<u>Pinnularia</u> <u>microstauron</u>
<u>Pinnularia</u> <u>viridis</u>
<u>Stauroneis</u> <u>anceps</u>
<u>Stauroneis</u> <u>phoenicenteron</u>

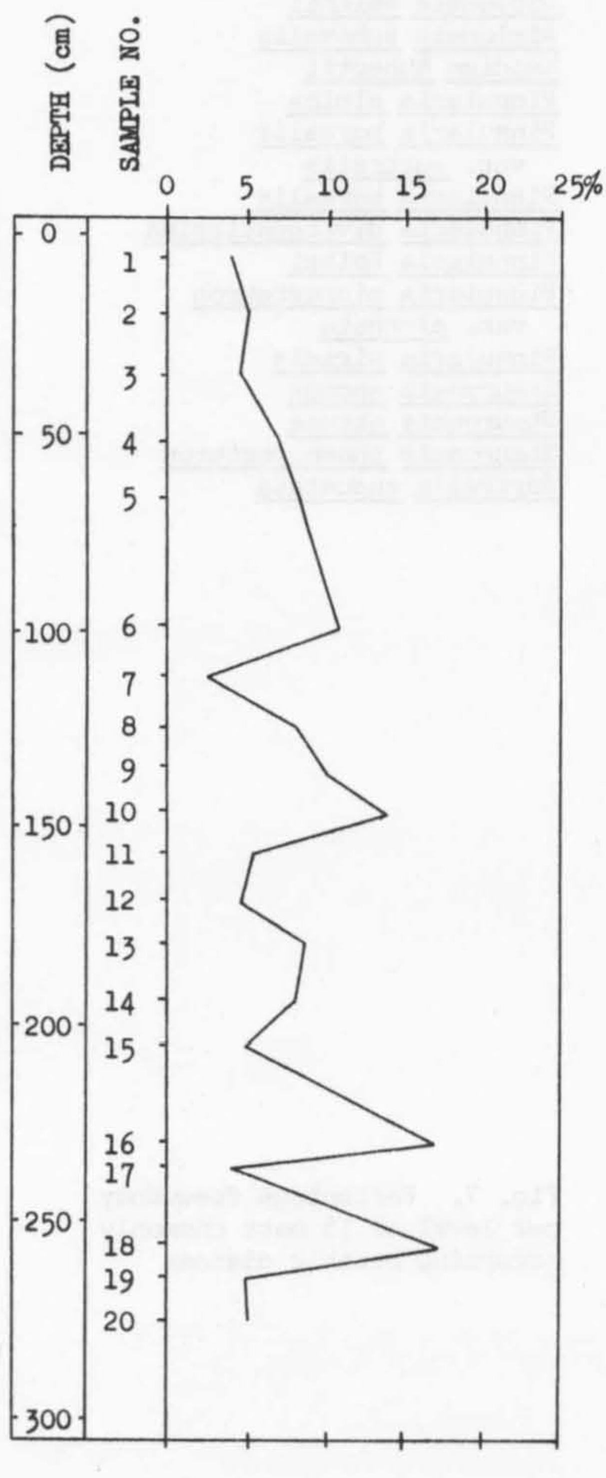

Fig. 8. Percentage frequency per level of 20 most commonly occurring acidophilous diatoms

Taxa:

Achnanthes lanceolata
Achnanthes Manguinii
Achnanthes minutissima
Amphora ovalis
Caloneis bacillum
Caloneis Marnieri
Caloneis ventricosa
Cymbella aequalis
Cymbella affinis
Diatoma vulgare
Diploneis subovalis
Fragilaria construens
  var. venter
Gomphonema angustatum
Gomphonema gracile
Melosira granulata
Navicula Schoenfeldii
Navicula seminulum
Nitzschia frustulum
Opephora Martyi
Rhopalodia gibberula
Stauroneis obtusa
Surirella angustata

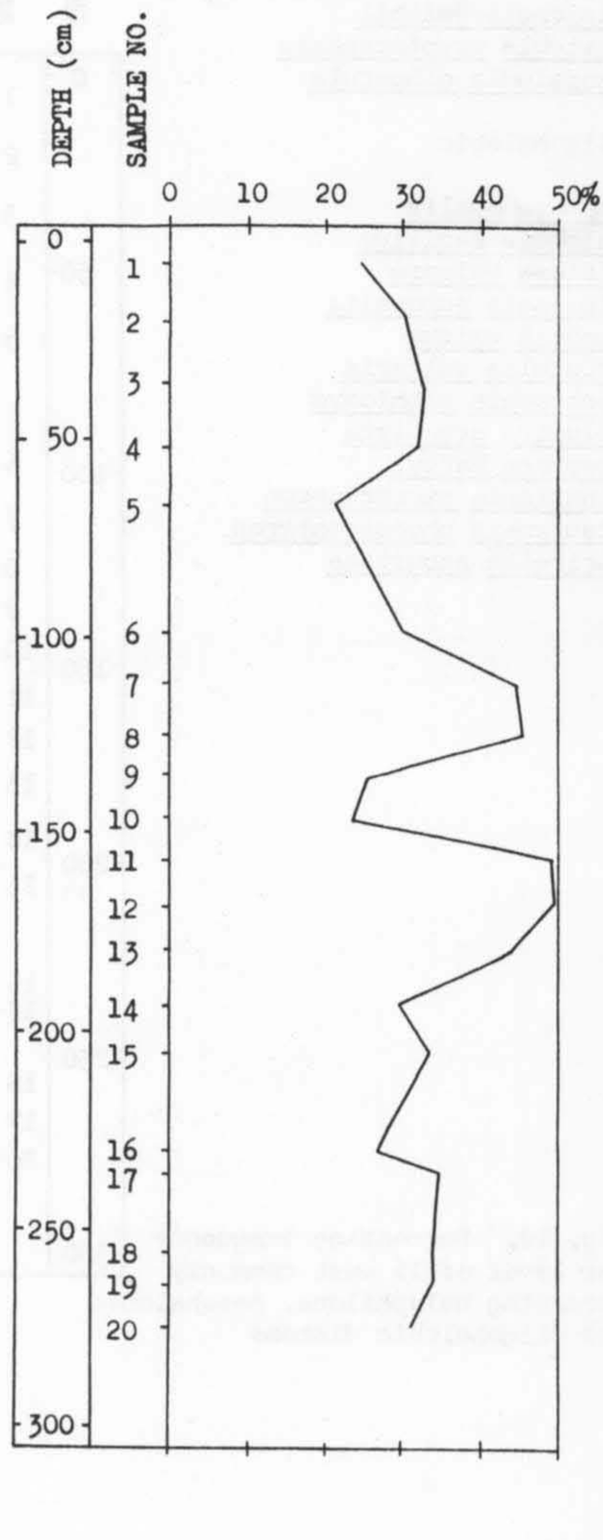

Fig. 9. Percentage frequency per level of 22 most commonly occurring alkaliphilous and alkalibiontic diatoms

Taxa:
Halophilous and Mesohalobic
Diploneis Smithii
Navicula cryptocephala
Rhopalodia gibberula

Oligohalobic

Amphora ovalis
Caloneis bacillum
Diatoma vulgare
Diploneis subovalis
Eunotia exigua
Frustulia vulgaris
Hantzschia amphioxys
Melosira granulata
Opephora Martyi
Pinnularia microstauron
Stauroneis phoenicenteron
Surirella angustata

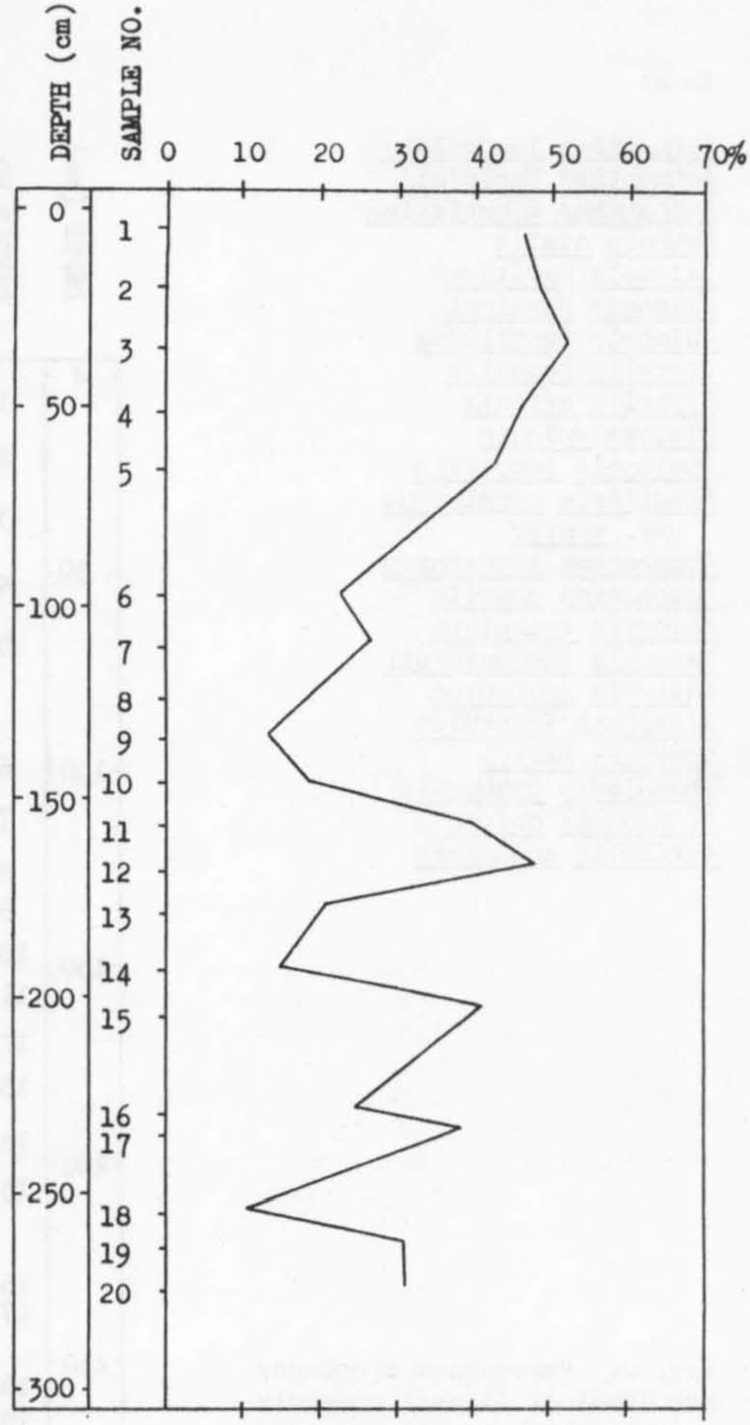

Fig. 10. Percentage frequency per level of 15 most commonly occurring halophilous, mesohalobic and oligohalobic diatoms

Taxa:

Achnanthes coarctata
Achnanthes lanceolata
Eunotia exiqua
Hantzschia amphioxys
Melosira granulata
Neidium Aubertii
Nitzschia ignorata
Pinnularia Kolbei
Pinnularia microstauron
Stauroneis obtusa

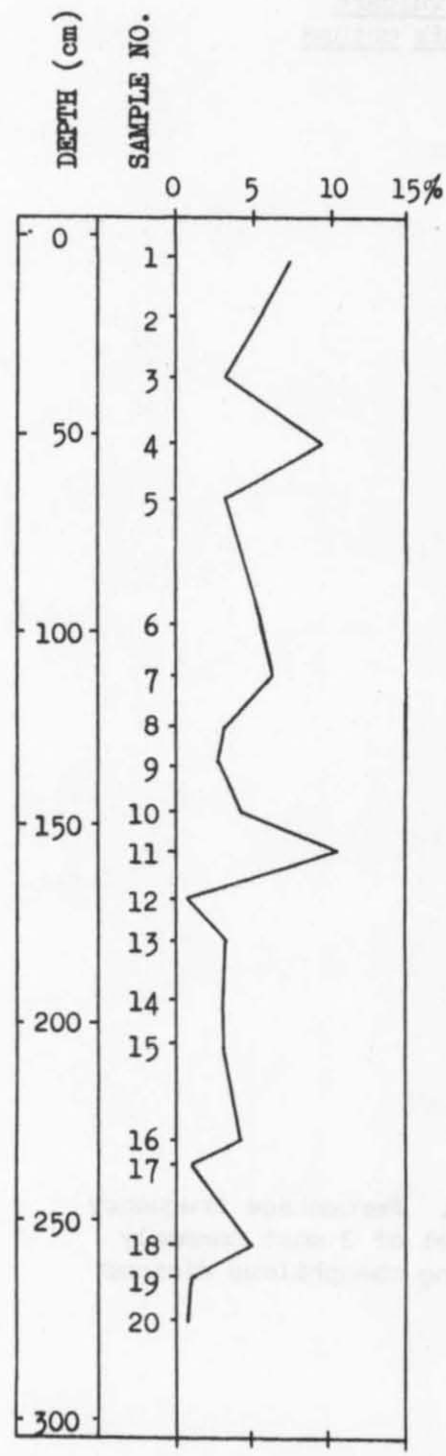

Fig. 11. Percentage frequency per level of 10 most commonly occurring aerophilous diatoms

Taxa:

Achnanthes lanceolata
Diatoma vulgare
Stauroneis obtusa

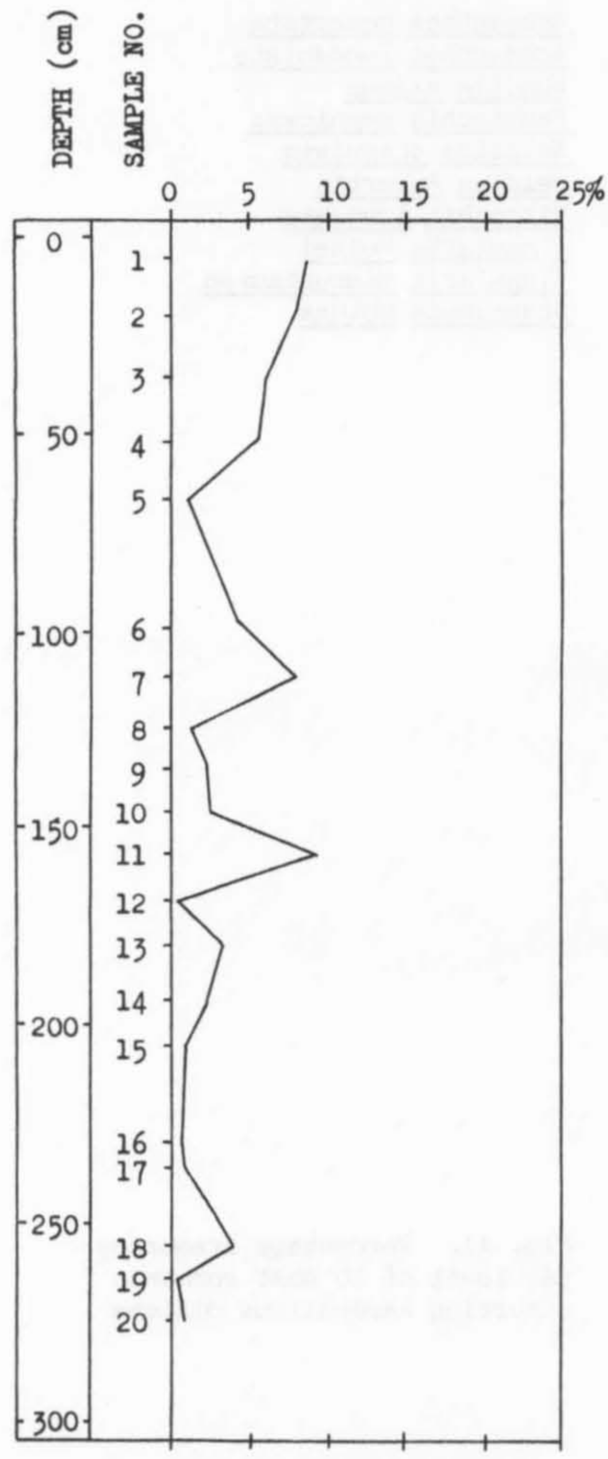

Fig. 12. Percentage frequency per level of 3 most commonly occurring rheophilous diatoms

Taxa:

<u>Caloneis bacillum</u>
<u>Surirella angustata</u>

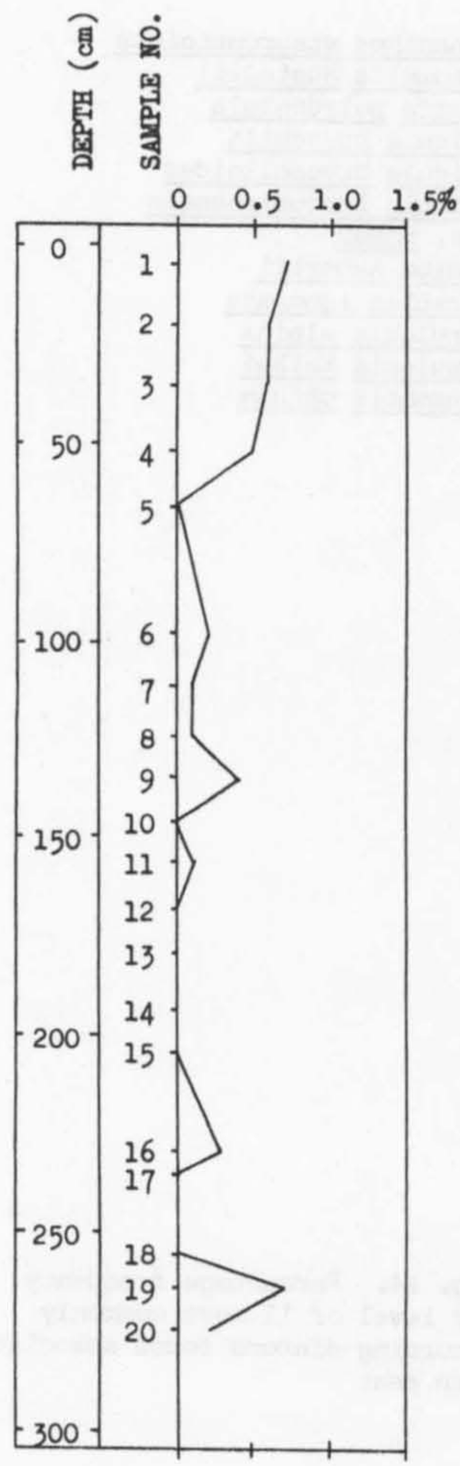

Fig. 13. Percentage frequency per level of 2 most commonly occurring crenophilous diatoms

Taxa:

Achnanthes stauroneioides
Diatomella Hustedtii
Eunotia polydentula
Navicula bryophila
Navicula bryophiloides
Navicula Kerquelenensis
fo. minor
Neidium Aubertii
Nitzschia ignorata
Pinnularia alpina
Pinnularia Kolbei
Stauroneis obtusa

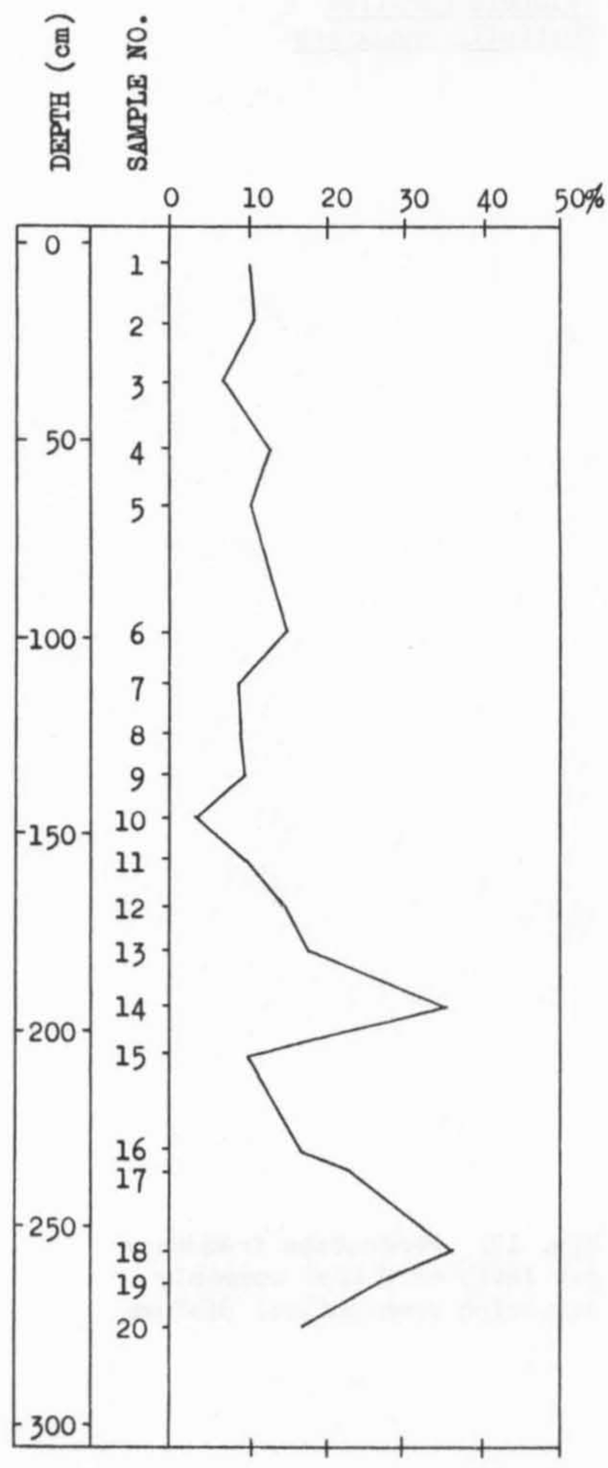

Fig. 14. Percentage frequency per level of 11 most commonly occurring diatoms found associated with peat

Taxa:

Diatoma vulgare
Diatomella Hustedtii
Eunotia pectinalis
Pinnularia borealis
Pinnularia divergentissima

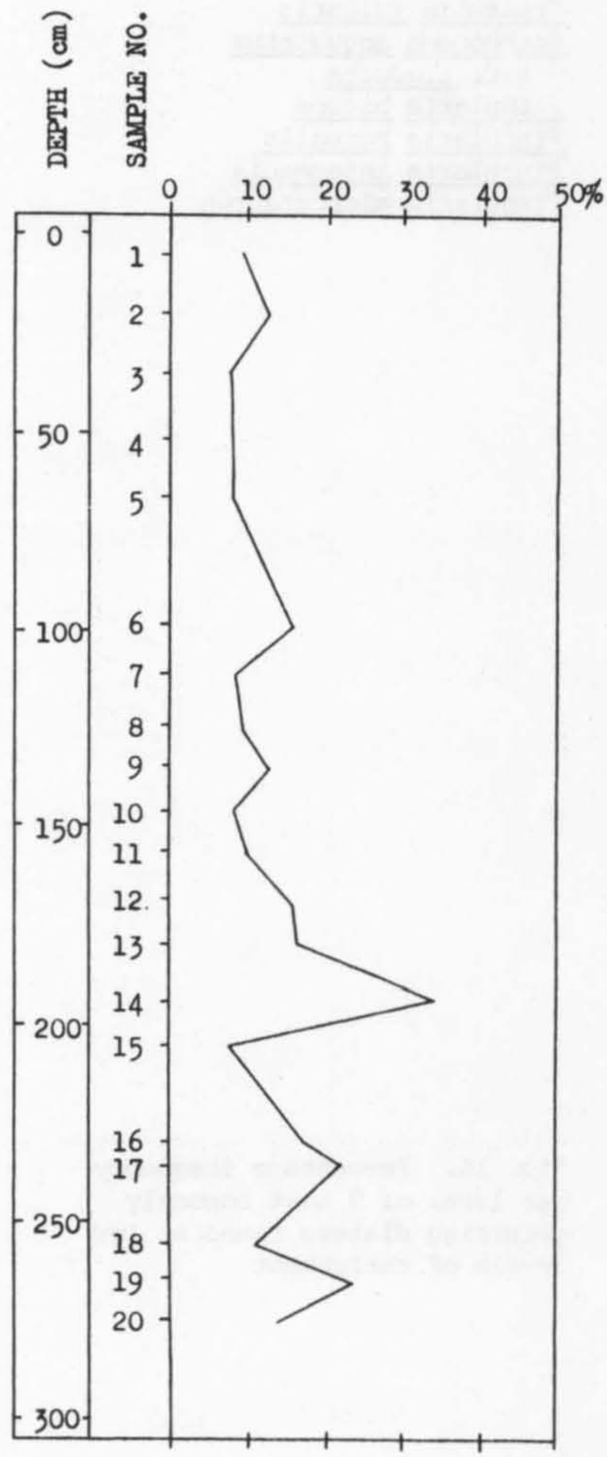

Fig. 15. Percentage frequency per level of 5 most commonly occurring diatoms found in cold water

Taxa:

Achnanthes lanceolata
Eunotia exigua
Eunotia pectinalis
Frustulia vulgaris
Gomphonema angustatum
  var. producta
Pinnularia biceps
Pinnularia borealis
Pinnularia intermedia
Pinnularia microstauron

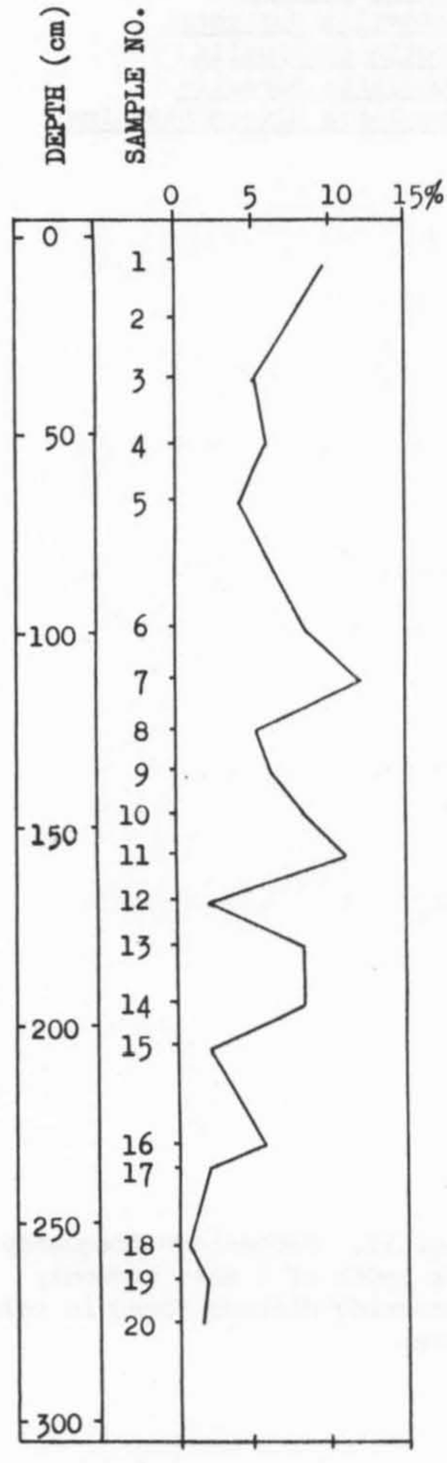

Fig. 16. Percentage frequency per level of 9 most commonly occurring diatoms found at low levels of enrichment

Taxa:

Achnanthes lanceolata
  var. elliptica
Achnanthes minutissima
Amphora ovalis
Caloneis bacillum
Diatoma vulgare
Diploneis Smithii
Diploneis subovalis
Eunotia pectinalis
Fragilaria construens
  var. venter
Frustulia vulgaris
Gomphonema gracile
Hantzschia amphioxys
Melosira granulata
Navicula cryptocephala
Navicula minima
Neidium Aubertii
Nitzschia frustulum
Nitzschia ignorata
Opephora Martyi
Pinnularia borealis
Pinnularia microstauron
Pinnularia subsolaris
Stauroneis phoenicenteron
Surirella angustata

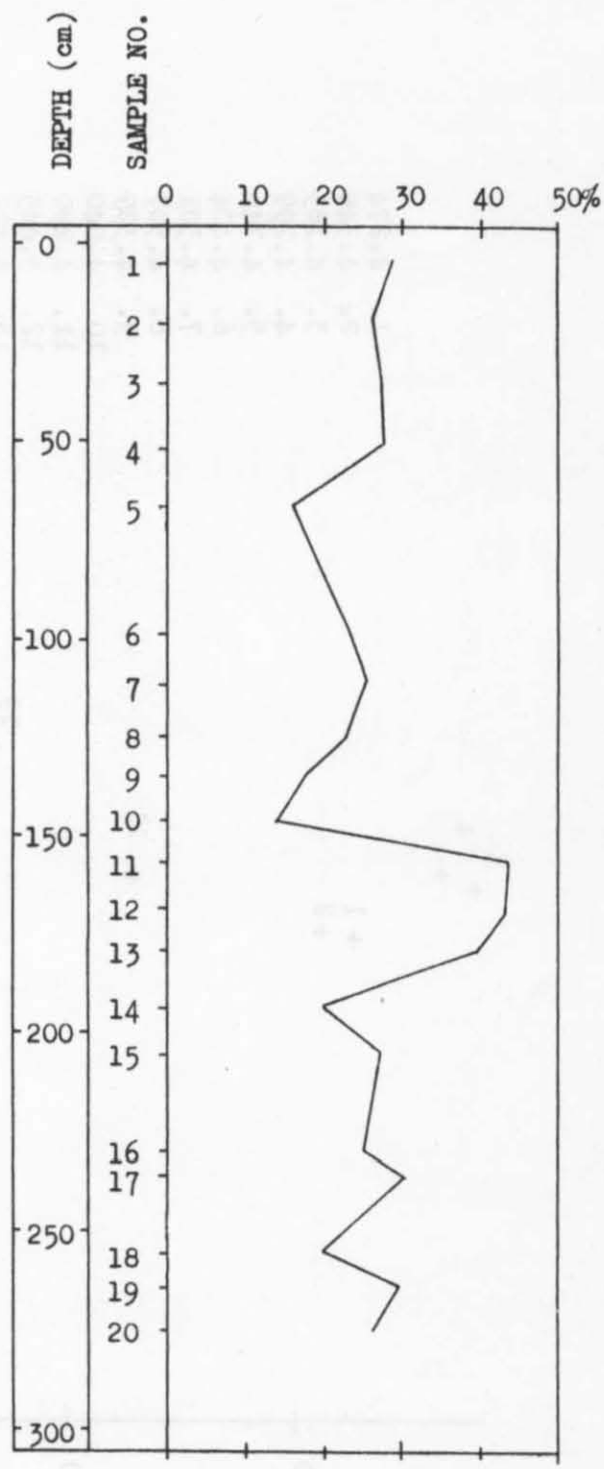

Fig. 17. Percentage frequency per level of 24 most commonly occurring diatoms found at high levels of enrichment

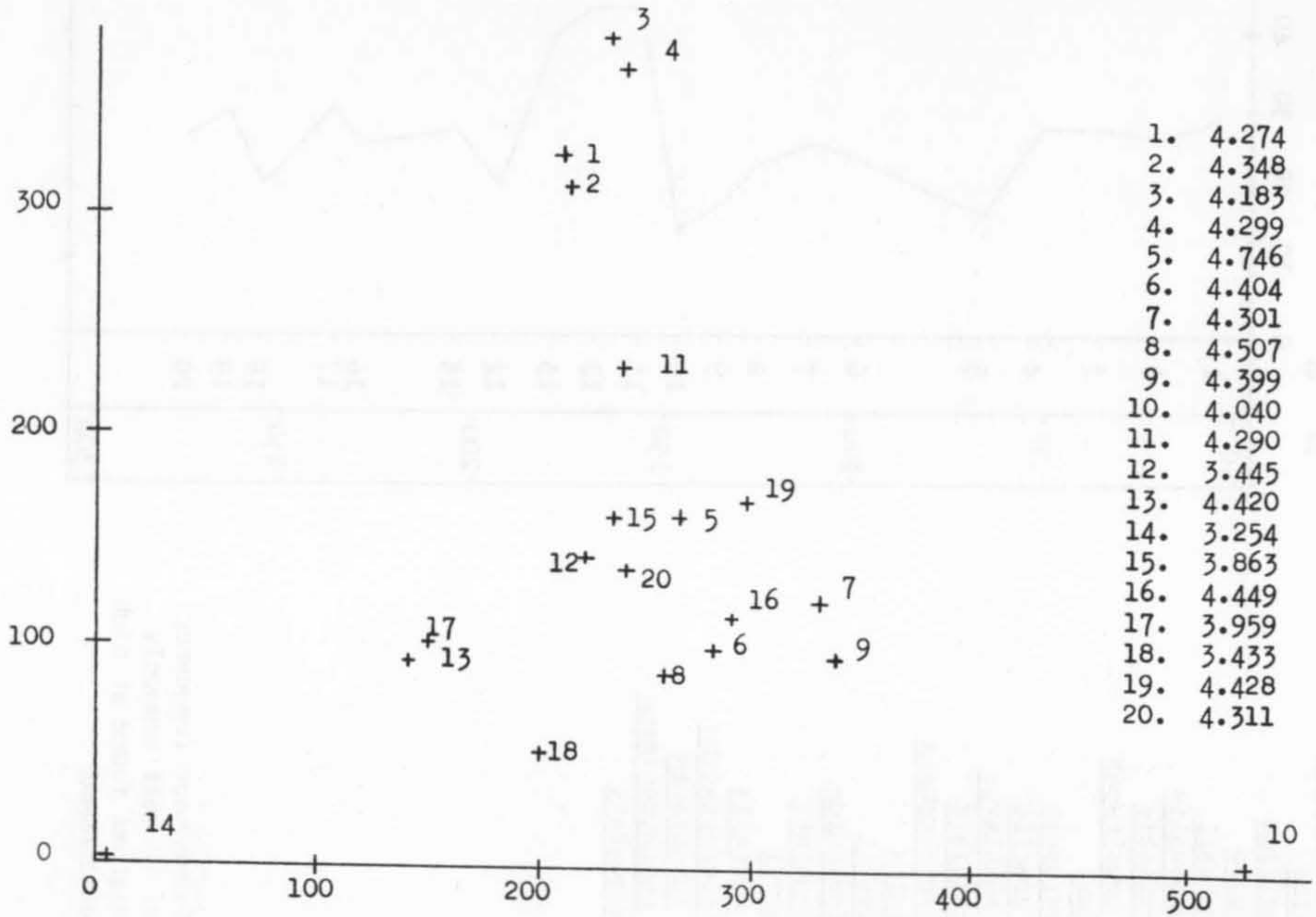

Fig. 18. Two-dimensional ordination by station and diversity index values by station

TABLE 1

Soil pH from 20 Kerguelen core levels

(Orion Research pH Meter)

Level	pH	Level	pH
1	5.7	11	5.4
2	5.0	12	4.8
3	5.6	13	5.3
4	5.9	14	4.9
5	5.4	15	5.0
6	5.3	16	5.1
7	5.1	17	5.1
8	4.8	18	4.8
9	4.7	19	4.9
10	5.1	20	5.3

DISCUSSION

Diatoms in Sediments

Pollen grains deposited in aquatic sediments, when frequencies of different genera are compared, may be good indicators of prevailing climatic conditions during the time of deposition, as well as keys to patterns of plant succession. Pollen deposition is influenced by factors such as wind and screening by other plants, and some plants produce more pollen than others. In spite of these problems pollen frequencies are extremely valuable in interpreting past conditions.

Diatom frustules are preserved in the same types of sediments as are pollen grains. Most of these frustules were indigenous in the water where the deposition occurred, although some of them may have washed or blown into the body of water from surrounding areas. A diatom taxon that occurred at a site in the past should be found in the sediments representative of that site and period, although alkaline environments may cause deterioration of some more delicate frustules (G. B. Collins, personal communication). Figure 2 shows the number of taxa per level to be relatively stable, so this sort of deterioration probably has not occurred in the Kerguelen material. Fragmentation of frustules in the layers where there was coarse sand did occur.

Diatoms for which ecological information is available in the literature may therefore be used to indicate past conditions of the aquatic environment. Many diatoms achieve optimum growth under specific ecological conditions, and some are considered by algal ecologists to be "indicators" of aquatic conditions (Appendix 2). By using the ecological classification systems of Kolbe (1927), Fjerdingstad (1965) and Hustedt (1937), along with ecological relationships observed to occur in nature and in the laboratory, diatom percentage frequency diagrams may be used in interpreting past events.

Classification Schemes

Several classification systems are used to describe ecological distribution of diatom taxa. A system based on pH described by Hustedt (1937) places diatoms into categories according to the acidity or alkalinity of the water in which they have been found growing. Alkalibiontic taxa are nearly always found in water with a pH above 7, and alkaliphilous taxa grow most frequently in water with a pH about 7, with the widest distribution above 7. Indifferent taxa occur with equal frequency on either side of pH 7 with no obvious "preference". Diatoms usually occurring below pH 7 are acidophilous, while those which nearly always occur at a pH below 7, most having a pH optimum of 5.5 and below, are acidobiontic.

A scheme based on association of certain taxa with salt (NaCl) concentration was described by Kolbe in 1927. A taxon common in slightly brackish waters (less than 5% NaCl concentration) is an oligohalobe, while a taxon occurring only in chloride-deficient waters is considered a halophobe. Taxa growing best in fresh water but also occurring in slightly brackish water are described as halophils. Mesohalobes are most often found in brackish water (NaCl concentration 5 - 20%), and euhalobes occur almost exclusively in water containing 30 - 40% salt.

A system categorizing diatom taxa according to degree of water current is also described by Hustedt (1937). Forms occurring exclusively in stagnant waters are limnobionts, those occurring usually in stagnant water are limnophils, and those found in either stagnant or running waters are considered indifferent. Rheophils are collected most often from running water, while rheobionts occur only in running water.

A saprobian system described by Fjerdingstad in 1965 is also used in ecological classification of diatom taxa. Organisms found only in heavily polluted waters are saprobiontic, those found most frequently in polluted waters, but also occurring elsewhere, are saprophilous. Taxa found generally in unpolluted areas but occurring sometimes in polluted conditions are saproxenous, and taxa found growing only in non-polluted areas are saprophobous.

These classification systems have been used widely, and are useful guidelines for placing diatom taxa into ecological categories. Stoermer et al. (1971) describe these schemes as useful in that they save space and provide a common format, but say that they may cause problems because many species either span several categories or straddle the boundary between two categories.

Diatoms in the Kerguelen Core

The diatoms found in the samples prepared from the lowest sediments of the Kerguelen core are predominantly alkaliphilous, as is the situation throughout the core. However, the greatest numbers of acidophilous individuals were found below level 12, where uniform peat deposition occurred (Fig. 8), and there are relatively fewer alkaliphilous taxa below level 15 (Fig. 9). The presence of *Eunotia monodon* and *Pinnularia divergentissima* as dominants at level 16 and *Pinnularia alpina* at level 18 (Appendix 4) along with high levels of the genus Eunotia (Fig. 3) indicate a more acidic situation at lower levels in the core than at higher levels.

No benthic diatoms occur as dominants above level 8. The benthic diatom which does occur as a dominant at lower levels is Diploneis subovalis, which is also associated with enriched situations. There are, in contrast, fewer numbers of planktonic and littoral diatoms at levels 15 and below (Figs. 5 and 6), while Fig. 7 shows an increasing trend in numbers of benthic diatoms from higher to lower core levels.

The highest percentages of peat-associated diatoms occur below level 10 (Fig. 14), where peat accumulation took place. Few diatoms associated with a low degree of enrichment are found below level 12 (Fig. 16), while high percentages of diatoms occurring in more enriched situations are found at level 11 and below (Fig. 17). Conditions of high decomposition of organics were occurring at this time (K. R. Everett, personal communication).

The upper core levels are characterized by sediments low in organics, mostly sand and silt. These levels are dominated by Fragilaria leptostauron var. dubia, Fragilaria construens var. venter, Fragilaria virescens var. subsalina, Opephora Martyi and Diatomella Hustedtii. Fragilaria is considered a planktonic genus, Opephora Martyi occurs in shallow water, and the genus Diatomella is found in cold, fast water and also in lakes. Melosira, a planktonic genus also considered aerophilous, has a significant peak at level 4 (Fig. 4). Clay also occurs at this point (Fig. 3) and this would indicate standing water at this time. Figure 5 shows high percentages of planktonic diatoms occurring above level 6, and Fig. 7 shows low percentages of benthic diatoms above level 6. Figure 12 demonstrates higher levels of rheophilous diatoms above level 12, and at the upper core levels other than level 4 silt and sand were being deposited, indicating moving water, or perhaps a drier situation at the site. Silt and sand might have been windblown into the basin during drier conditions.

The highest percentages of alkaliphilous diatoms and lowest percentages of acidophilous diatoms, occur at the upper core levels. This indicates a change from a more acidic to less acidic situation after past deposition ceased.

Greater concentrations of aerophilous diatoms occur at levels 12 and above. These could be further evidence of a drier period in Kerguelen's history. Young and Schofield (1973) believe this dry period was also cold, as evidenced by comparison of pollen frequencies from levels along the Kerguelen core. A reverse correlation exists between their climatic reconstruction using pollen evidence, and Fig. 15 showing percentage frequency per level of diatoms occurring in cold water. The highest concentrations of these 5 taxa occur below level 12, during a period described as warmer than present by Young and Schofield. This reverse correlation could be due to the fact that so few taxa were considered in this category.

More diatoms occurring at low levels of enrichment (Fig. 16) and fewer diatoms found at high levels of enrichment (Fig. 17) were found in the upper sediments. There were also fewer peat-associated taxa (Fig. 14) found at higher levels in the core.

SUMMARY AND CONCLUSION

Analysis of diatom communities from 20 levels along a sediment core from Kerguelen Island shows a progression from a wet, organically enriched, acid condition to a drier, less organic, alkaline condition at the site during the past 10,000 years since deglaciation. This analysis shows a close correlation between physical stratigraphy of the core and diatom ecology.

By analyzing pollen frequencies from the same Kerguelen core material, Young and Schofield (1973) suggest that a transition from a climate warmer and wetter than present to a cold, dry climate began about 5,000 years B.P.

Although it is possible to substantiate the transition from a wetter to a drier climate with both diatom and pollen evidence, there does not seem to be a correlation between cooling temperatures in the southern hemisphere and past diatom populations on Kerguelen Island.

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APPENDIX 1.

List of the 105 Taxa Recorded (Counts for each taxon for each of the 20 levels are given in Larson, 1973). An asterisk (*) identifies the 86 taxa found on Kerguelen by Bourelly and Manguin (1954).

*Achnanthes abundans (Bourelly & Manguin, 1954, p. 19)

Achnanthes austraica (Hustedt, 1930, p. 201)

Achnanthes coarctata (Patrick & Reimer, 1966, p. 277)

*Achnanthes flexella (Ktz.) Brun. (Patrick & Reimer, 1966, p. 260)

*Achnanthes Germainii (Bourelly & Manguin, 1954, p. 20)

*Achnanthes lanceolata (Breb.) Grun. (Patrick & Reimer, 1966, p. 269)

*Achnanthes lanceolata var. elliptica (Hustedt, 1930, p. 208)

*Achnanthes Manguinii Hust. (Bourelly & Manguin, 1954, p. 22)

*Achnanthes microcephala (Ktz.) Grun. (Patrick & Reimer, 1966, p. 250)

*Achnanthes minutissima Ktz. var. cryptocephala Grun. (Patrick & Reimer, 1966, p. 253)

*Achnanthes modesta (Bourelly & Manguin, 1954, p. 22)

*Achnanthes pseudolanceolata (Bourelly & Manguin, 1954, p. 22)

*Achnanthes stauroneioides (Bourelly & Manguin, 1954, p. 23)

*Amphora ovalis Ktz. (Hustedt, 1930, p. 342)

*Caloneis bacillum (Grun.) Meresch. (Patrick & Reimer, 1966, p. 586)

*Caloneis Marnieri (Bourelly & Manguin, 1954, p. 23)

*Caloneis ventricosa (Bourelly & Manguin, 1954, p. 24, as C. silicula)

*Coccineis Kerguelenensis (Bourelly & Manguin, 1954, p. 18)

*Coccineis placentula Ehr. (Patrick & Reimer, 1966, p. 240)

Cymbella aequalis Smith (Hustedt, 1930, p. 361)

*Cymbella affinis Ktz. (Hustedt, 1930, p. 362)

*Cymbella lacustris (Ag.) Cl. var. australis (Bourelly & Manguin, 1954, p. 38)

*Cymbella microcephala Grun. (Hustedt, 1930, p. 351)

*Cymbella nodosa (Bourelly & Manguin, 1954, p. 59)

*<u>Diatoma</u> <u>vulgare</u> Bory var. <u>Ehrenbergii</u> Grun. (Bourelly & Manguin, 1954, p. 17)

*<u>Diatomella</u> <u>Hustedtii</u> (Bourelly & Manguin, 1954, p. 23)

*<u>Diploneis</u> <u>Smithii</u> (Bréb.) Cl. (Patrick & Reimer, 1966, p. 410)

*<u>Diploneis</u> <u>subovalis</u> Cl. (Hustedt, 1930, p. 254)

<u>Diploneis</u> sp.

<u>Eunotia</u> <u>arcus</u> (Patrick & Reimer, 1966, p. 212)

*<u>Eunotia</u> <u>exigua</u> (Bréb.) Ralfs. (Patrick & Reimer, 1966, p. 215)

*<u>Eunotia</u> <u>monodon</u> Ehr. var. <u>major</u> (W. Sm.) Hust. (Bourelly & Manguin, 1954, p. 18)

<u>Eunotia</u> <u>pectinalis</u> (Patrick & Reimer, 1966, p. 204)

*<u>Eunotia</u> <u>polydentula</u> Brun. var. <u>mediotumida</u> (Bourelly & Manguin, 1954, p. 18)

*<u>Eunotia</u> <u>polydentula</u> Brun. var. <u>perpusilla</u> Grun. (Bourelly & Manguin, 1954, p. 18)

<u>Fragilaria</u> <u>capucina</u> (Patrick & Reimer, 1966, p. 118)

*<u>Fragilaria</u> <u>construens</u> var. <u>venter</u> (Ehr.) Grun. (Patrick & Reimer, 1966, p. 125)

*<u>Fragilaria</u> <u>leptostauron</u> (Ehr.) Hust. (Patrick & Reimer, 1966, p. 124)

*<u>Fragilaria</u> <u>leptostauron</u> var. <u>dubia</u> (Patrick & Reimer, 1966, p. 124)

*<u>Fragilaria</u> <u>pinnata</u> Ehr. (Patrick & Reimer, 1966, p. 127)

*<u>Fragilaria</u> <u>vaucheriae</u> var. <u>capitellata</u> Grun. (Bourelly & Manguin, 1954, p. 17)

*<u>Fragilaria</u> <u>virescens</u> var. <u>subsalina</u> Grun. (Bourelly & Manguin, 1954, p. 18)

*<u>Frustulia</u> <u>pulchra</u> Germ. (Bourelly & Manguin, 1954, p. 23)

*<u>Frustulia</u> <u>rhomboides</u> (Ehr.) De Toni (Patrick & Reimer, 1966, p. 306)

*<u>Frustulia</u> <u>vulgaris</u> Thw. (Patrick & Reimer, 1966, p. 309)

*Gomphonema angustatum (Ktz.) Ralfs. var. producta Grun. (Hustedt, 1930, p. 373)

*Gomphonema gracile (Ehr. (Hustedt, 1930, p. 376)

Gomphonema sp. 1

*Hantzschia amphioxys (Hustedt, 1930, p. 394)

*Melosira granulata (Ehr.) Ralfs. (Hustedt, 1930, p. 87)

*Navicula arcuata Heid. et Kolbe (Bourelly & Manguin, 1954, p. 26)

*Navicula bicephala Hust. (Bourelly & Manguin, 1954, p. 26)

*Navicula bryophila B. Petersen (Bourelly & Manguin, 1954, p. 27)

*Navicula bryophiloides (Bourelly & Manguin, 1954, p. 27)

Navicula confervacea (Patrick & Reimer, 1966, p. 476)

Navicula contenta var. biceps (Hustedt, 1930, p. 277)

Navicula contenta (Hustedt, 1930, p. 277)

*Navicula cryptocephala Kutz. (Hustedt, 1930, p. 295)

*Navicula elegans W. Sm. var. cuspidata Cl. (Bourelly & Manguin, 1954, p. 28)

Navicula elginensis (Patrick & Reimer, 1966, p. 524)

Navicula elginensis var. australis (Patrick & Reimer, 1966, p. 524)

*Navicula genticulata Germ. (Bourelly & Manguin, 1954, p. 28)

*Navicula Kerguelenensis Heid. et Kolbe (Bourelly & Manguin, 1954, p. 28)

*Navicula Kerguelenensis fo. minor (Hust.) Bourelly & Manguin, 1954, p. 30)

*Navicula linearis (O. Mull.) Frenguel. (Bourelly & Manguin, 1954, p. 30)

*Navicula minima Grun. var. atomoides Grun. (Bourelly & Manguin, 1954, p. 31)

Navicula mutica (Patrick & Reimer, 1966, p. 454)

*Navicula Schoenfeldii Hust. (Bourelly & Manguin, 1954, p. 32)

*Navicula seminulum Grun. (Hustedt, 1930, p. 272)

Navicula sp. 1

Navicula sp. 2

*Neidium Aubertii (Bourelly & Manguin, 1954, p. 24)

*Nitzschia dissipata (Ktz.) Grun. (Hustedt, 1930, p. 412)

*Nitzschia frustulum (Ktz.) Grun. var. Kerguelenensis (Bourelly & Manguin, 1954, p. 42)

*Nitzschia ignorata Krass. var. longissima (Bourelly & Manguin, 1954, p. 40)

*Opephora Martyi Herib. (Hustedt, 1930, p. 132)

*Pinnularia alpina W. Sm. var. Kerguelenensis (Heid. et Kolbe) Frenguel. (Bourelly & Manguin, 1954, p. 35)

*Pinnularia appendiculata (Patrick & Reimer, 1966, p. 593)

*Pinnularia Backebergii (Bourelly & Manguin, 1954, p. 34)

Pinnularia biceps (Patrick & Reimer, 1966, p. 599)

*Pinnularia borealis Ehr. (Patrick & Reimer, 1966, p. 618)

*Pinnularia borealis var. australis (Bourelly & Manguin, 1954, p. 34)

*Pinnularia Braunii (Grun.) Cl. var. amphicephala (A. Mayer) Hust. (Patrick & Reimer, 1966, p. 594)

*Pinnularia Brebissonii (Patrick & Reimer, 1966, p. 615)

*Pinnularia divergentissima (Grun.) Cl. (Patrick & Reimer, 1966, p. 616)

*Pinnularia intermedia Lagerst. (Patrick & Reimer, 1966, p. 617)

*Pinnularia Kolbei (Bourelly & Manguin, 1954, p. 35)

*Pinnularia leptosoma Grun. (Hustedt, 1930, p. 316)

*Pinnularia microstauron (Ehr.) Cl. (Patrick & Reimer, 1966, p. 597

*Pinnularia microstauron var. australis (Bourelly & Manguin, 1954, p. 36)

*Pinnularia microstauron var. biundulata (Hustedt, 1930, p. 320)

*Pinnularia microstauron var. elongata (Bourelly & Manguin, 1954, p. 36)

*Pinnularia obscura Krasske (Patrick & Reimer, 1966, p. 617)

*Pinnularia subsolaris (Grun.) Cl. fo. Kerguelenensis (Bourelly & Manguin, 1954, p. 36)

*Pinnularia viridis (Nitz.) Ehr. var. semicruciata (Grun.) Cl. (Bourelly & Manguin, 1954, p. 38)

*Rhopalodia gibberula (Patrick & Reimer, 1966, p. 391)

*Stauroneis anceps Ehr. (Patrick & Reimer, 1966, p. 361)

*Stauroneis anceps fo. linearis (Ehr.) Cl. (Patrick & Reimer, 1966, p. 362)

Stauroneis ignorata (Patrick & Reimer, 1966, p. 366)

*Stauroneis legumen Ehr. var. integra (Bourelly & Manguin, 1954, p. 26)

*Stauroneis obtusa Lagerst. (Bourelly & Manguin, 1954, p. 26)

*Stauroneis phoenicenteron Ehr. (Patrick & Reimer, 1966, p. 359)

*Stauroneis Smithii Grun. var. incisa Pantoc. (Patrick & Reimer, 1966, p. 366)

*Surirella angustata Ktz. var. constricta Hust. (Bourelly & Manguin, 1954, p. 42)

Synedra sp.

APPENDIX 2. Ecological Information for 56 Taxa Included in Figure 3

Achnanthes abundans

Unknown (Haworth, 1972)

Achnanthes coarctata

Aerophil, found on soil, rocks, and mosses; pH indifferent (Patrick and Reimer, 1966); pH under 7 (Cholnoky, 1968).

Achnanthes lanceolata

Littoral, indifferent, eurytrophic (Manguin, 1952); aerophil, abundant from peat bog (Bourelly and Manguin, 1954); found in flowing water, neutral to alkaline, does not appear with organic enrichment (Patrick and Reimer, 1966); abundant from mosses and liverworts (Gandhi, 1966); common in dry lakes (Van Landingham, 1966).

Achnanthes Manguinii

Genus is planktonic (Taylor, 1929); peat-associated, alkaliphilous (Bourelly and Manguin, 1954).

Achnanthes minutissima

Principally occurring in alkaline waters, fresh water, saprophilous (Fjerdingstad, 1965); may indicate organic pollution (G. B. Collins, personal communication, 1971).

Achnanthes modesta

Unknown (Manguin, 1952).

Achnanthes pseudolanceolata

Littoral (Bourelly and Manguin, 1954).

Achnanthes stauroneioides

Fairly common from peat bog (Bourelly and Manguin, 1954).

Amphora ovalis

Littoral, well-developed on calcareous sediments, less so on peaty sediments (Round, 1957); indifferent, alkaliphilous, oligosaprobic, (Hustedt, 1955); on rocks with wet masses of bryophytes (Gandhi, 1966); alkaliphilous, found in brackish water (0.75% NaCl) (Fjerdingstad, 1965); alkaliphilous (Haworth, 1972).

Caloneis bacillum

Benthic (Round, 1957); littoral, oligohalobe, crenophil, eurytrophic (Manguin, 1952); from detritus, slimy incrustations of rock pools (Gandhi, 1966); often from standing alkaline water (Patrick and Reimer, 1966).

Caloneis Marnieri

Genus occurs in alkaline water, fresh or brackish (G. B. Collins, personal communication, 1971).

Caloneis ventricosa

Littoral (Manguin, 1952); pools, puddles, ditches, sometimes wet mosses (Gandhi, 1966).

Cymbella aequalis

pH 7.3-7.5 (Cholnoky, 1968).

Cymbella affinis

Alkaliphilous (Patrick, 1962); pH 7.8-8 (Cholnoky, 1968).

Diatoma vulgare

Found in brackish water up to 4.0% NaCl, oligohalobic, saproxenous, alkalibiontic, rheophilous (Hustedt, 1955); optimum pH 7.8, indifferent, sewage tolerant (Fjerdingstad, 1965); occurs in cool, flowing water, perhaps of higher mineral content (Patrick and Reimer, 1966); pH 8.2 (Cholnoky, 1968); genus is found in cold water, common in plankton (G. B. Collins, personal communication, 1971).

Diatomella Hustedtii

Abundant from lake, also found associated with peat (Bourelly and Manguin, 1954); genus occurs in cold, fast, oligotrophic waters (G. B. Collins, personal communication, 1971).

Diploneis Smithii

High nutrient levels, genus is linked to high sulfate levels (Round, 1957); estuarine, mesohaline, benthic and epontic on weeds; common (Crosby and Ferguson-Wood, 1959); marine littoral, marginal detritus (Gandhi, 1966); found in brackish water (Patrick and Reimer, 1966); found in brackish water (Cholnoky, 1968); littoral, mesohalobe, eurytrophic (Manguin, 1952).

Diploneis subovalis

Littoral, oligohalobe, eurytrophic (Manguin, 1952); benthic, high nutrient levels (Round, 1957); fresh water (Gandhi, 1966); pH 7.3-8 (Cholnoky, 1968).

Eunotia exiqua

Genus is epiphytic on moss (Conger, 1939); littoral, aerophilous, oligohalobe (Manguin, 1952); acidity indicator (Palmer, 1962); found with mosses in acid water of low mineral content (Patrick and Reimer, 1966); pH 5.2-5.3 (Cholnoky, 1968); genus found in acid waters (G. B. Collins, personal communication, 1971).

Eunotia monodon

pH 5 (Cholnoky, 1968).

Eunotia pectinalis

Littoral (Manguin, 1952); found in cooler regions, low mineral content, oligotrophic to eutrophic (Patrick and Reimer, 1966); acid to circumneutral water, will tolerate some calcium carbonate (Andrews, 1970).

Eunotia polydentula

pH 5.2-5.5 (Cholnoky, 1968).

Fragilaria construens var. venter

Littoral, planktonic, indifferent, eurytrophic (Manguin, 1952); genus is planktonic (Taylor, 1929); rare in dry lakes (Van Landingham, 1966); pH 7.7-7.8 (Cholnoky, 1968); genus common in lake plankton (G. B. Collins, personal communication, 1971); alkaliphilous (Haworth, 1972).

Fragilaria leptostauron var. dubia

Moss-associated (Bourelly and Manguin, 1954); no information (Patrick and Reimer, 1966); F. leptostauron has optimum pH of 8 (Cholnoky, 1968).

Fragilaria vaucheriae var. capitellata

Common, littoral (Bourelly and Manguin, 1954); found in lakes and ponds (Patrick and Reimer, 1966).

Fragilaria virescens var. subsalina

Littoral and planktonic from lake, found associated with peat bog (Bourelly and Manguin, 1954); F. virescens pH optimum below 7 (Cholnoky, 1968).

Frustulia pulchra

Rare littoral species from river and two lakes (Bourelly and Manguin, 1954); genus found in acid waters (G. B. Collins, personal communication, 1971).

Frustulia vulgaris

Littoral, oligohalobe, indifferent (Manguin, 1952); indicates low calcium (Round, 1957); associated with slimy matter and detritus, wet mosses (Gandhi, 1966); found in water of low mineral content which is circumneutral (Patrick and Reimer, 1966); in brackish water, pH 7.5-8 (Cholnoky, 1968).

Gomphonema angustatum var. producta

Littoral (Bourelly and Manguin, 1954); genus occurs in rocky lakes at low nutrient levels (Round, 1957); G. angustatum pH ranges from 7.5 to 7.7 (Cholnoky, 1968); genus is littoral (G. B. Collins, personal communication, 1971).

Gomphonema gracile

Associated with vegetable detritus (Gandhi, 1966); pH 7.2-7.4 (Cholnoky, 1968).

Hantzschia amphioxys

Littoral, ubiquitous (Manguin, 1952); estuarine, brackish water, occasionally in more marine waters (Crosby and Ferguson-Wood, 1959); common soil diatom (Van Landingham, 1966); H_2S tolerant (Palmer, 1962; saprophilous (Fjerdingstad, 1965); brackish, pH range 5.5-9.4 (Cholnoky, 1968).

Melosira granulata

Genus is planktonic (Taylor, 1929; littoral, planktonic, oligohalobe (Manguin, 1952); wide distribution in aquatic habitats, also in non-aquatic, abundant in dry lakes (Van Landingham, 1966); fresh water, optimum pH above 7, mesotrophic, eutrophic, 7-35^{o} C temperature range (Patrick, 1962); pH 7.9-8.2 (Cholnoky, 1968); common in eutrophic lakes, ponds and streams, often occurring in great abundance (Andrews, 1970).

Navicula arcuata

Littoral (Bourelly and Manguin, 1954).

Navicula bryophila

Common from peat bog (Bourelly and Manguin, 1954); pH about 6 (Cholnoky, 1968).

Navicula bryophiloides

Abundant from peat bog (Bourelly and Manguin, 1954).

Navicula genticulata

Very rare from lake (Bourelly and Manguin, 1954).

Navicula Kerguelenensis fo. minor

Common in lake plankton and peat bog (Bourelly and Manguin, 1954).

Navicula Schoenfeldii

Rare from lake (Bourelly and Manguin, 1954); pH 7.5-8 (Cholnoky, 1968).

Navicula seminulum

pH 8.4 (Cholnoky, 1968).

Neidium Aubertii

Aerophil, common from peat bog (Bourelly and Manguin, 1954); benthic, best development of genus in higher nutrient lakes (Round, 1957); genus usually found in acid water (G. B. Collins, personal communication, 1971).

Nitzschia frustulum var. Kerguelenensis

N. frustulum common in detritus (Gandhi, 1966); occurs in brackish water above pH 7 (Cholnoky, 1968); genus may indicate organic pollution (G. B. Collins, personal communication, 1971).

Nitzschia ignorata

Aerophil, common from peat bog (Bourelly and Manguin, 1954); best development in rocky lakes (Round, 1957); H_2S tolerant (Palmer, 1962); on detritus (Gandhi, 1966); pH 6.5 (Cholnoky, 1968).

Opephora Martyi

Littoral, oligohalobe (Manguin, 1952); common in lakes, not in river plankton (Bourelly and Manguin, 1954); not common in dry lakes (Van Landingham, 1966); fresh water, shallow mesotrophic (Patrick and Reimer, 1966); brackish water, pH 7.8-8.2 (Cholnoky, 1968).

Pinnularia alpina var. Kerquelenensis

Genus is usually benthic (Taylor, 1929; common in peat bog (Bourelly and Manguin, 1954); genus usually benthic in acid water (G. B. Collins, personal communication, 1971).

Pinnularia biceps

Occurring in fresh water of low mineral content (Patrick and Reimer, 1966).

Pinnularia borealis var. australis

Found in plankton, not littoral (Bourelly and Manguin, 1954).

Pinnularia borealis

Occurs in cool water of low mineral content (Patrick and Reimer, 1966); cool, fresh water, low mineral content, circumneutral pH, mesotrophic, still or running water (Patrick, 1962); pH under 6 (Cholnoky, 1968).

Pinnularia divergentissima

Occurs in cold water, often in mountains (Patrick and Reimer, 1966).

Pinnularia Kolbei

Aerophil, common in peat bog (Bourelly and Manguin, 1954).

Pinnularia microstauron var. elongata

Littoral, oligohalobe, eurytrophic (Manguin, 1952); ubiquitous (Round, 1957); common on soils (Van Landingham, 1966); fresh water; low mineral content, oligotrophic to mesotrophic (Patrick, 1962); oligotrophic, slightly acid water (Patrick and Reimer, 1966); iron tolerant (Palmer, 1962); pH below 7, brackish (Cholnoky, 1968).

Pinnularia viridis var. semicruciata

Littoral (Manguin, 1952); ubiquitous (Round, 1957); pH optimum for P. viridis 5.6-6 (Cholnoky, 1968).

Rhopalodia gibberula

Littoral, ubiquitous (Manguin, 1952); occurs in salt water (Hustedt, 1955); brackish water, pH 8.2 (Cholnoky, 1968); genus usually in alkaline waters (G. B. Collins, personal communication, 1971).

Stauroneis anceps

Littoral, oligohalobe, indifferent (Manguin, 1952); occurs in fresh water (Crosby and Ferguson-Wood, 1959); widespread eurytrophic species, pH indifferent (Patrick and Reimer, 1966); pH below 7 (Cholnoky, 1968); widespread in fresh water, tolerant of a wide range of pH (Andrews, 1970); genus benthic in streams (G. B. Collins, personal communication, 1971); indifferent (Haworth, 1972).

Stauroneis obtusa

Aerophil, common from peat bog (Bourelly and Manguin, 1954); running or otherwise well-aerated water, alkaliphilous, salt-indifferent or halophobe (Patrick and Reimer, 1966); pH under 6 (Cholnoky, 1968).

Stauroneis phoenicenteron

Littoral, oligohalobe, indifferent (Bourelly and Manguin, 1954); benthic; genus has highest production in lakes richest in nutrients, is sensitive to small changes in the environment (Round, 1957); fresh water (Crosby and Ferguson-Wood, 1959); oligohalobe, pH indifferent (Patrick and Reimer, 1966); pH 6.8 (Cholnoky, 1968); widespread in fresh water, tolerant of a wide range of pH (Andrews, 1970).

Surirella angustata var. _constricta_

Genus benthic (Taylor, 1929); genus occurs more frequently in productive lakes (Round, 1957); littoral, planktonic, oligohalobe, crenophil (Manguin, 1952); _S. angustata_ has optimum pH of 7.5 (Cholnoky, 1968).

APPENDIX 3. Core Description

Abbreviated Profile Description, Core No. 1 (see Fig. 1 for location)

Kerguelen Island

Collected by Steven Young, 1971
Described by Kaye Everett, Institute of Polar Studies, The Ohio State University

Description from surface down; depths are centimeters from top. Core moist.

0-31	Pale brown, 10YR 6/3, silt loam; medium yellowish red, 5YR 4/8 mottles (common); medium to coarse angular blocky structure; ped surfaces slightly more red; roots plentiful; some organic stain along ped surfaces, lower boundary abrupt, even.
31-35	Pale brown, 10YR 6/3, loamy medium to fine sand; lower boundary abrupt, even.
35-49	Brown, 10YR 5/3, silt loam, some fine mottles; roots common, lower boundary clear, even.
49-61	Dark brown 7.5YR 4/2 to yellowish brown 10YR 5/6, medium to coarse sandy loam grading upward to loam; roots common; lower boundary abrupt, even.
61-67	Brown to dark yellowish brown, 10YR 4/3-4/4, silt loam; upper 1.5 cm silty clay loam with a few fibers; lower boundary abrupt, even.
67-143	Alternating bands of dark reddish brown 5YR 2/2 sapric organic dark grayish brown 10YR 4/2 to dark reddish brown 5YR 2/2 silt and/or organic silt; bands slightly contorted, especially lower 10 cm; fine fibers (stems and roots) are abundant, increasing in both size and amount between 98 and 123 cm, roots nearly absent above 91 cm (between 108 and 110 cm is a dipping band of coarse loamy sand); lower boundary abrupt, uneven.
143-161	Contorted and mixed horizon, colors range from brown 10YR 5/3 through dark yellowish brown 10YR 3/4 to very dark grayish brown 10YR 3/2, silty clay loam and coarse sand with ghost granules; root and stem fibers are plentiful, especially between 160 and 158 cm; lower boundary clear, even.

161-184	Alternating dipping to slightly contorted bands of dark reddish brown 5YR 2/2, very dark grayish brown 10YR 3/2 and dark brown 10YR 3/3 sapric organic and/or silty mineral soil; bands range from a few mm to several cm. All boundaries are clear, one thin 3-mm band of coarse sand and one thin 0.5 cm band of coarse to very coarse sand; lower boundary clear to gradual, dipping.
184-190.5	Black 5YR 2/1 dark reddish brown 5YR 2/2 sapric organic matter; some fine fibers; lower boundary abrupt, even.
190.5-212	Yellowish brown 10YR 5/4 (general color) coarse and medium loamy sand with some fine rounded to sub-rounded ghost pebbles; wavy, thin intercalations of organic silt, especially between 91-94 cm and 105.5-111.5 cm intervening zone is mostly coarse loamy sand; lower boundary abrupt, even.
212-255	Dark reddish brown 5YR 2/2 finely fibrous sapric peat with numerous, slightly contorted bands of sand and silt with volcanic granules (thickness of bands ranges to 1 cm); most band boundaries clear to abrupt, even.
255-283	Dark brown, 10YR 4/3 to dark yellowish brown 10YR 4/4 medium and fine sandy loam with small inclusions of organic matter; roots and fibers increase toward upper horizon.
283-285	Dark brown 7.5 YR 3/2 organic clay till (fossil soil zone). Lower boundary abrupt, even.
285-303	Dark grayish brown, 10YR 4/2, pebbly clay till; all pebbles are ghosts; non-sticky; roots abundant.
303-321	Sample not examined, but appears to be till.

APPENDIX 4. Diatom taxa occurring in concentrations of 5% or more at each level.

Level 1

	%
Fragilaria leptostauron var. dubia	26.7
Fragilaria construens var. venter	7.5
Diatomella Hustedtii	7.2
Opephora Martyi	7.0
Achnanthes lanceolata	6.6
Fragilaria virescens var. subsalina	5.1

Level 2

	%
Fragilaria leptostauron var. dubia	26.0
Diatomella Hustedtii	7.9
Fragilaria virescens var. subsalina	7.2
Opephora Martyi	6.9
Fragilaria vaucheriae var. capitellata	6.1
Fragilaria construens var. venter	5.6

Level 3

Fragilaria leptostauron var. dubia	31.0
Fragilaria construens var. venter	10.0
Opephora Martyi	6.3
Fragilaria vaucheriae var. capitellata	5.1

Level 4

Fragilaria leptostauron var. dubia	32.0
Fragilaria virescens var. subsalina	11.4
Fragilaria construens var. venter	7.8
Diatomella Hustedtii	5.7
Opephora Martyi	5.1

Level 5

Fragilaria virescens var. subsalina	16.2
Fragilaria leptostauron var. dubia	8.8
Diatomella Hustedtii	5.5

Level 6

Navicula arcuata	17.2
Diatomella Hustedtii	13.6
Fragilaria leptostauron var. dubia	10.9
Fragilaria virescens var. subsalina	8.2
Fragilaria construens var. venter	6.8

Level 7

Navicula arcuata	17.0
Fragilaria construens var. venter	11.0
Fragilaria virescens var. subsalina	8.2
Fragilaria leptostauron var. dubia	7.6
Achnanthes Manguinii	6.9
Achnanthes lanceolata	5.9
Cymbella affinis	5.9
Diatomella Hustedtii	5.8

Level 8

Diploneis subovalis	11.0
Cymbella affinis	9.0
Achnanthes pseudolanceolata	7.6
Diatomella Hustedtii	7.4
Navicula arcuata	5.7
Navicula Schoenfeldii	5.6

Level 9

Achnanthes pseudolanceolata	21.0
Navicula arcuata	13.0
Fragilaria leptostauron var. dubia	8.6
Diatomella Hustedtii	8.2
Diploneis subovalis	5.8
Fragilaria virescens var. subsalina	5.0

Level 10

Navicula arcuata	31.5
Achnanthes pseudolanceolata	16.5
Fragilaria virescens var. subsalina	13.1
Fragilaria vaucheriae var. capitellata	10.7
Navicula Schoenfeldii	5.5

Level 11

Fragilaria construens var. venter	23.5
Fragilaria leptostauron var. dubia	10.9
Achnanthes lanceolata	8.6
Diatomella Hustedtii	7.9
Fragilaria virescens var. subsalina	5.7
Achnanthes pseudolanceolata	5.5

Level 12

Fragilaria construens var. venter	35.1
Diatomella Hustedtii	14.0
Achnanthes pseudolanceolata	7.9
Fragilaria virescens var. subsalina	5.7

Level 13

Diatomella Hustedtii	14.6
Amphora ovalis	10.8
Diploneis subovalis	9.6
Fragilaria leptostauron var. dubia	5.9

Level 14

Diatomella Hustedtii	34.5
Amphora ovalis	8.6
Gomphonema angustatum var. producta	5.1

Level 15

Fragilaria construens var. *venter*	20.6
Navicula genticulata	14.2
Achnanthes pseudolanceolata	8.6
Diatomella Hustedtii	6.7
Achnanthes abundans	5.1

Level 16

Navicula arcuata	15.4
Fragilaria construens var. *venter*	12.8
Diatomella Hustedtii	11.2
Fragilaria leptostauron var. *dubia*	8.4
Fragilaria virescens var. *subsalina*	7.1
Eunotia monodon	6.7
Achnanthes pseudolanceolata	5.6
Pinnularia divergentissima	5.0

Level 17

Diatomella Hustedtii	21.0
Fragilaria construens var. *venter*	18.0
Diploneis subovalis	5.8
Fragilaria virescens var. *subsalina*	5.5

Level 18

Diploneis subovalis	16.0
Pinnularia alpina	15.0
Diatomella Hustedtii	11.0
Navicula arcuata	7.0
Navicula bryophiloides	6.4

Level 19

Fragilaria construens var. *venter*	15.0
Fragilaria virescens var. *subsalina*	10.5
Navicula arcuata	5.6

Level 20

Fragilaria construens var. *venter*	15.0
Diatomella Hustedtii	12.8
Achnanthes pseudolanceolata	8.4
Fragilaria virescens var. *subsalina*	7.2
Achnanthes modesta	5.8
Navicula genticulata	5.6
Fragilaria leptostauron var. *dubia*	5.3
Navicula arcuata	5.0
Achnanthes minutissima	5.0